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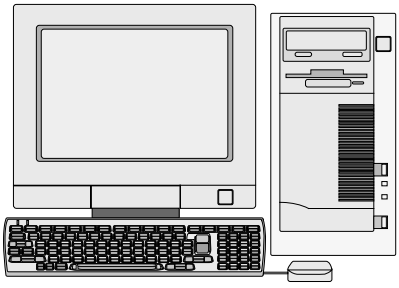

# THE SUITABILITY OF USING RECOVERED PAPER AS A DIRECT FOOD PACKAGING

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**Abstract**

The objective of this study was evaluation of the suitability of recycled paper materials for direct food contact applications. Safety evaluation of various recycled paper grades was conducted in order to identify the contaminants that are present in certain types of recycled papers which have the ability to migrate into the food and thus potentially endanger consumers' health. For the purpose of the investigation, three different types of recovered papers had been submitted to a chemical deinking flotation and the handsheets that were formed after each flotation deinking trial were analyzed on the presence of residual chemical contaminants: heavy metals (Cd, Pb, Hg), primary aromatic amines, phthalates, diisopropylnaphthalenes (DIPN) and polychlorinated biphenyls (PCB).
The conducted research showed that most common contaminants present in the analysed papers were DIPNs and phthalates which were found at highest concentrations in brown packaging grades. However, according to present toxicological assessments, detected amounts of DIPNs and phthalates do not impose a health risk to the consumers. Research thus demonstrated that all tested papers regarding the analyses done within this study are proved suitable to be used in direct contact with food.

**Key words:** *Chemical deinking flotation, Food packaging, Health safety, Recycled fibres*

**Rezumat**

Obiectivul acestui studiu a fost de a evalua cele mai adecvate hârtii de ambalaj din fibre reciclate pentru a fi utilizate în aplicații destinate contactului cu produsele alimentare. Evaluarea atentă a unor sortimente de hârtii din fibre reciclate s-a făcut în scopul de a identifica contaminanții prezenți care au capacitatea de a migra din ambalaj în aliment şi potențialul acestora de a pune în pericol sănătatea consumatorilor. Pentru investigații au fost folosite trei tipuri de hârtii din fibre reciclate care au fost supuse descernelizării prin flotație, din care s-au făcut foi de laborator care au fost apoi analizate din punct de vedere al contaminanților reziduali: metale grele (Cd, Pb, Hg), amine aromatice primare, ftalați, diizopropilnaftalen (DIPN) şi compuşi bifenilpoliclorurați (PCB). În urma analizei rezultatelor obținute s-a constatat că ftalații şi compuşii pe bază de diizopropilnaftalen (DIPNs) au fost prezenți în concentrația cea mai mare, în special la mostrele de hârtii de ambalaj neînălbite. Cu toate acestea, potrivit normelor toxicologice în vigoare, nivelul cantității de DIPNs şi ftalați înregistrat nu implică risc pentru sănătatea consumatorilor. Prin urmare, pe baza analizelor efectuate, cercetările au demonstrat că toate probele de hârtie testate în cadrul acestui program experimental pot fi utilizate pentru ambalaje care intră în contact direct cu alimentele.

**Cuvinte cheie:** *Descernelizare prin flotație; Ambalaj alimentar; Siguranța alimentară; Fibre reciclate*

# INTRODUCTION

Paper is the most recycled packaging material in the EU with a recycling rate of 78% [1]. When used as food packaging, recycled paper must be safe, i.e. it should not give rise to migration of substances in quantities that might endanger human health. This requirement comes from the EU Framework Regulation (EC) No 1935/2004 which applies to all materials intended to come in direct contact with food [2]. However, the suitability of using recycled fibres in food contact applications is still being largely debated among the scientific community - since it is difficult to exclude exposure to traces of ink chemicals, varnishes, adhesives, and other potentially harmful substances in recycled fibres [3].

Besides general requirements laid out in the Framework Regulation, food packaging materials made from paper and board are not yet covered by harmonized European legislation. In the absence of a specific directive, the paper and board food packaging supply chain relies on the national legislation for paper and board published in the Netherlands, Italy and France or on the BfR Recommendation XXXVI [4] published in Germany. Existing regulations define the chemicals that are allowed in the manufacture of paper and board and set limits for various contaminants (heavy metals, polychlorinated biphenyls, phthalates, etc.) in finished products [5]. In Croatia, paper and board food contact materials are regulated by the Ordinance on sanitary safety of materials and articles intended to come into direct contact with foodstuffs [6]. However, in addition to current national laws and existing regulations for paper and board food contact materials, guideline documents such as Nordic report on paper and board food contact materials developed by the Nordic Council of Ministers can also be found [7]. Such documents are aimed at manufacturers of paper and board materials and articles intended for food contact and are designed to provide guidance for establishing compliance with the Framework Regulation (EC) No 1935/2004.

This paper deals with the safety issues of recycled-fibre based materials and their suitability for direct food contact. Safety evaluation of various recycled paper grades was conducted in order to identify the contaminants that are present in certain types of recycled papers which have the ability to migrate into food and thus potentially endanger consumers' health. Evaluation of the food contact suitability was conducted on selected classes of recycled papers that were produced either industrially or in laboratory conditions.

# RESEARCH METHODS

In this experiment, three types of recovered paper grades were chosen to be recycled by means of laboratory deinking flotation.

First type of recovered paper chosen to be deinked by flotation was fluting paper obtained from industry. Brown packaging grades, such as fluting paper, usually contain high amounts of recycled fibres that originate mostly from old corrugated containers (OCCs) and mixed paper and board grades. Fluting paper was unprinted, but still it contained a high amount of ink residues, fillers and other impurities since it had been produced from recycled fibres that did not undergo chemical cleaning i.e. deinking flotation during recycling. Therefore, the objective of this experiment was to evaluate possible decrease in the amount of chemical contaminants in the composition of the pulp after conducting a laboratory deinking flotation. The composition and the properties of fluting paper are shown in Table 1.

Second group of recovered paper mix that was chosen to be deinked by flotation consisted of old newspapers (ONP), old magazines (OMG), offset printed cardboard (CMYK) and offset printed wood free paper (printed in black). The prints were mixed in equal proportions of dry fibrous matter.

For the third recovered paper sample, a mix of office print-outs printed by laser printers in black and in color – CMYK (50:50) using dry toner inks was selected to be recycled by means of deinking flotation. Black prints were printed using the Ingede A4 letter Gray Testpage whereas for color prints the Ingede A4 letter CMYK Testpage was used. The Navigator brand office paper was used as a substrate for all printing trials. The office paper characteristics are shown in Table 2.

*Table 1 Fluting paper characteristics*

| Fluting | |
|---|---|
| **Basis weight** | 170 $gm^{-2}$ |
| **Ash content** | 15.0 % |
| **Bulk** | 1.56 $cm^3g^{-1}$ |
| **Composition** | Semi-chemical pulp (60%), the rest being the mixed papers and boards containing maximum of 40% of newspapers and magazines (EN 643: 1.02). |

*Table 2 Office paper characteristics*

| Navigator Universal Office Paper | |
|---|---|
| **Composition** | 72% chemical pulp, 20% fillers, 4% binders, 4% moisture |
| **Basis weight** | 80 $gm^{-2}$ |
| **Ash Content** | 14.5 % |
| **Bulk** | 1.31 $cm^3g^{-1}$ |

Laser prints were printed with the HP 1010 printer (for black prints) and color (CMYK) prints were printed with the LEXMARK C920 printer. The prints were submitted to accelerated ageing (72 h, 60±3°C) prior to conducting laboratory deinking flotation.

**Deinking flotation**

For the laboratory deinking flotation (Figure 1) three recovered paper samples were prepared named hereafter: fluting sample, mix sample and office print-outs. The samples were recycled separately but followed the same procedure: 75 grams of absolutely dry paper was cut in 2 x 2 cm strips and put in the pulper. By adding two litres of deionised water at a temperature of 60 ºC, the consistency of pulp was set to 3.75%. Afterwards, the deinking chemicals were added: 5% NaOH (22.90 ml), 1.5% $H_2O_2$ (20 ml), 6% $Na_2SiO_3$ (17.30 ml), 0.5% DTPA (0.38 g) and 3% surfactant (2.25 g). The industrial deinking process was simulated with these amounts of added chemicals. The obtained pH was between 10.8-11.

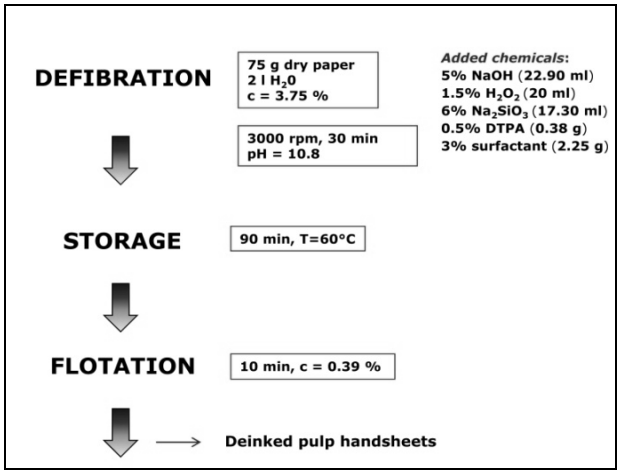


*Figure 1 Deinking flotation procedure scheme*

The pulp was disintegrated in the pulper at 3000 rpm for 30 minutes and was subsequently stored for 90 minutes at a temperature of 60 $^0$C.

The suspension was afterwards diluted with tap water up to the volume of 19 litres and transferred to the flotation cell, where it was flotated for 10 minutes. During the flotation process, the flotation froth was collected manually and removed from the cell. After the flotation, the deinked pulp handsheets were formed according to the TAPPI 205 standard method [8].

**Food contact analyses**

Food contact analyses were conducted on the deinked pulp handsheets formed after deinking of fluting sample, mix sample and office print-outs, as well as on the original fluting paper. Food contact analyses comprised determination of heavy metal contents (cadmium, lead and mercury), primary aromatic amines, diisopropylnaphthalene (DIPN), phthalates and polychlorinated biphenyls (PCB) from aqueous or organic solvent extracts of paper.

In order to determine heavy metals, cold-water extracts were prepared from all paper samples in accordance with the EN 645:1993 [9]. The determination of metal ions (cadmium, lead and mercury) in the cold-water extracts was carried out in accordance with the EN 12497 and EN 12498 [10, 11]. Detection of metals was conducted by atomic absorption spectroscopy (AAS).

For determination of primary aromatic amines, the paper samples were extracted in dichloromethane. The concentrations of primary aromatic amines (expressed as aniline) in solvent extracts were determined by liquid chromatography–mass spectrometry (LC-MS).

The determination of diisopropylnaphthalene content (DIPN) was carried out in accordance with the EN 14719:2005 [12]. The content of total diisopropylnaphthalene (DIPN) was determined by solvent extraction (dichloromethane) of the paper sample and analysed by gas chromatography with mass selective detection (GC-MS), using diethylnaphthalene as an internal standard.

For the determination of phthalates, the paper samples were extracted in dichloromethane. The total phthalate content in solvent extract was determined by gas chromatography with mass selective detection (GC-MS).

The determination of polychlorinated biphenyls (PCB) was carried out in accordance with the ISO 15318:1999 standard [13]. The paper samples were extracted with boiling ethanolic sodium hydroxide solution. An aliquot of the

extract was mixed with water and afterwards subjected to liquid-solid partitioning on a disposable C18 solid phase extraction cartridge followed by elution with hexane. The present PCBs were quantified by means of gas chromatography with electron-capture detection (GC-EDC).

The results of conducted analyses were compared to the quantitative restrictions laid down in the German BfR Recommendations (chapter XXXVI) and/or Croatian Ordinance on sanitary safety of materials and articles intended to come into direct contact with foodstuffs with which they had to comply with. However, in case when the German or Croatian regulations did not specify clear limits for tested compounds, the results obtained by chemical analyses were compared to proposed restrictions laid down in the Nordic report on paper and board food contact materials.

## RESULTS AND DISCUSSION

The results of metal ions determination (Cd, Pb and Hg) in the cold-water extracts are presented in Table 3.

*Table 3 Amounts of metal ions determined in cold-water extracts (DP- deinked pulp)*

| **Amount in water extract** | **Hg** | **Cd** | **Pb** |
|---|---|---|---|
| | **mg/kg paper** | | |
| ***Limit*** | **0.3** | **0.5** | **3** |
| Fluting paper | <0.0001 | <0.0002 | <0.002 |
| Fluting paper DP handsheet | <0.0001 | <0.0002 | <0.002 |
| Mix sample DP handsheet | <0.0001 | <0.0002 | <0.002 |
| Office print-outs DP handsheet | <0.0001 | <0.0002 | <0.002 |

According to the German BfR Recommendations and the Croatian Ordinance on sanitary safety of materials and articles intended to come into direct contact with foodstuffs, the transfer of metal ions into foodstuffs must not exceed 0.5 mg per kg of paper (Cd); 3 mg per kg of paper (Pb); 0.3 mg per kg of paper (Hg). Testing is not necessary for paper and board intended to come into contact with dry, non-fatty foodstuffs.

As shown in the Table 3, all detected amounts of metal ions were actually found below the quantification limit of the instrument, which leads to the conclusion that there is no danger whatsoever of a migration of these compounds from the paper materials into the food.

The amounts of polychlorinated biphenyls (PCB) and primary aromatic amines determined in solvent extracts are presented in Table 4.

*Table 4: Amounts of PCBs and primary aromatic amines in solvent extracts (DP- deinked pulp)*

| **Amount in water extract** | **PCB** | **Primary aromatic amines** |
|---|---|---|
| | **mg/kg paper** | |
| ***Limit*** | **2 mg/kg** | **0.1 mg/kg** |
| Fluting paper | <0.02 | <0.05 |
| Fluting paper DP handsheet | <0.02 | <0.05 |
| Mix sample DP handsheet | <0.02 | <0.05 |
| Office print-outs DP handsheet | <0.02 | <0.05 |

According to the Croatian Ordinance on sanitary safety of materials and articles intended to come into direct contact with foodstuffs, finished products must not contain more than 2 mg of PCB per kg paper. On the other hand, German BfR Recommendations do not impose the testing of PCBs in finished paper, so no limits for PCBs are set within the existing German regulation.

Furthermore, according to the German BfR Recommendations, primary aromatic amines must not be detectable in the extract of the finished product. However, the detection limit still has to be defined. On the other hand, the Croatian Ordinance requires that the content of these substances must be below the limit of detection which is set to 0.1 mg of primary aromatic amines per kg of paper. Testing is not required for paper and board intended to come into contact with dry, non-fatty foodstuffs.

The results of the detected amounts of polychlorinated biphenyls (PCB) and primary aromatic amines in solvent extracts (Table 4) show that all detected concentrations of analysed compounds were also found below the quantification limit of the instrument.

The results of diisopropylnaphthalene (DIPN) and total phthalate content determination are presented in Table 5.

*Table 5*: *DIPN content and total phthalate content in solvent extracts of papers (DP- deinked pulp)*

| Amount in water extract | DIPN | Total phthalate content |
|---|---|---|
| | mg/kg paper | |
| Fluting paper | 15.0 | 15.0 |
| Fluting paper DP handsheet | 9.2 | 4.5 |
| Mix sample DP handsheet | 2.6 | 3.2 |
| Office print-outs DP handsheet | <0.5 | 6.2 |

The presence of DIPN in recycled paper originates from the use of recovered paper grades that include carbonless copy paper and thermal paper from office waste in which DIPN is used as solvent for the ink system. DIPN may not be completely removed by the treatment of recycled fibres and thus may be present in finished paper and board materials [14].

The presented results show that the highest concentrations of DIPNs were found in fluting paper (15 mg/kg) and that conducted deinking flotation reduced the content of DIPNs by almost 40% as detected in the fluting deinked pulp handsheet. The concentrations of DIPNs detected in deinked pulp handsheet of the mix sample were much lower (2.6 mg/kg) whereas the concentrations of DIPNs in the office print-outs deinked pulp were found to be below the detection limit (<0.5 mg/kg).

As regards to the determination of the total phthalate content, the fluting paper was once again found to be most contaminated sample having the concentration of phthalates of 15 mg/kg. Furthermore, the conducted deinking flotation reduced the phthalate content by 70 % as detected in the fluting deinked pulp handsheet. Phthalates were also found in the deinked pulp handsheets of the mix sample and office print-outs. Phthalates present in recycled paper and board originate from the printing inks, adhesives and lacquers applied to the material in the previous use of the paper [15, 16].

German BfR Recommendations, as well as the Croatian Ordinance on sanitary safety of materials and articles intended to come into direct contact with foodstuffs, require that the content of DIPN in finished paper should be as low as technically possible. It is obvious that neither the Croatian nor the German regulations specify a clear limit of permitted levels of DIPN in finished paper material. The results obtained by chemical analyses were therefore compared to the maximum limit set in the Nordic report on paper and board food contact materials. The Nordic guideline proposes that the level of DIPN should not exceed the limit of 1.33 mg of DIPNs per $dm^2$ of paper. Since in this case the maximum limit is expressed as weight/area unit, whereas the results obtained by an analytical measurement provided the weight/weight results, a conversion to weight/area units had to be done. The conversion was done by taking into account the actual grammage of analysed paper (Equation 1).

$$Qa = (Qm \times G)/10^5 \qquad (1)$$

*where:*

*Qa* is concentration of substance in paper expressed as mg/dm²,

*Qm* is concentration of substance in paper expressed as mg/kg,

*G* is grammage of paper as expressed as g/m².

As regards the regulations related to the residual amounts of phthalates in food contact paper, the permitted limit of the total phthalate content in paper material, expressed as a group restriction, was found in the Nordic guideline, whereas in the German and Croatian regulations the restriction limits were set only for individual phthalates. Hence, the Nordic guideline was used for the interpretation of obtained results. Nordic guideline imposes that the level of total phthalate content should not exceed the limit of 0.25 mg of phthalates per $dm^2$ of paper.

The results of DIPN and total phthalate content present in analysed paper samples expressed as $mg/dm^2$ of material are presented in Table 6 and 7.

*Table 6 DIPN content present in 1dm² of tested material (DP – deinked pulp)*

| Sample | Grammage ($g/m^2$) | DIPN ($mg/dm^2$) |
|---|---|---|
| | | *Limit* 1.33 $mg/dm^2$ |
| Fluting paper | 170 | 0.0255 |
| Fluting paper DP handsheet | 100 | 0.0092 |
| Mix sample DP handsheet | 100 | 0.0026 |
| Office print-outs DP handsheet | 100 | - |

*Table 7: Total phthalate content present in 1dm$^2$ of tested material (DP – deinked pulp)*

| Sample | Grammage (g/m$^2$) | Total phthalate content (mg/dm$^2$) |
|---|---|---|
| | | *Limit* 0.25 mg/dm$^2$ |
| Fluting paper | 170 | 0.0255 |
| Fluting paper DP handsheet | 100 | 0.0045 |
| Mix sample DP handsheet | 100 | 0.0032 |
| Office print-outs DP handsheet | 100 | 0.0062 |

The results of detected DIPNs in analysed paper samples expressed as mg/dm$^2$ of material indicate that all detected concentrations of DIPNs are much lower than the maximum amount allowed (1.33 mg/dm$^2$). The latter means that all of these paper samples, as far as this food contact suitability parameter is concerned, are considered suitable to be used in direct contact with food. Likewise, the results of phthalate content in tested papers show that all detected levels of phthalates in the analysed samples are also found much lower than the maximum permitted limit (0.25 mg/dm$^2$). Therefore, it can be concluded that all analysed papers, according to this food contact suitability parameter, are considered suitable to be used in direct contact with food.

## CONCLUSIONS

The conducted research showed that the most common contaminants present in the recycled papers are diisopropylnaphthalenes (DIPNs) and phthalates. Other evaluated contaminants, such as heavy metals (Cd, Pb and Hg), primary aromatic amines, polychlorinated biphenyls (PCBs) could not be quantified by available analytical methods i.e. were found at extremely low concentrations.

While comparing the detected amounts of DIPNs and phthalates in the analyzed papers to the quantitative restrictions laid down in the German or Croatian regulations, it was impossible to estimate whether those levels of chemicals impose a risk to human health due to the incomplete and imprecise regulations. However, when compared to the maximum limits proposed within the Nordic report on paper and board food contact materials, all detected concentrations were much below the limits proposed by Nordic guideline. It can therefore be concluded that all tested papers regarding the analyses done within this research are found suitable to be used in direct contact with foods. Nevertheless, additional analyses, such as determination of mineral oils in recycled fibre materials, must be conducted to further confirm their suitability for direct food contact.

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# ON QUALITY REQUIREMENTS OF TISSUE PAPERS

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**Rezumat**

Hârtiile şi produsele papetare igienico-sanitare diferă substanțial în privința proprietăților, de hârtiile obişnuite. Cele mai apreciate caracteristici sunt absorbția apei şi moliciunea. Aceste caracteristici sunt optimizate prin alegerea corespunzătoare a materiei prime şi a tehnologiei de fabricație. Pentru fabricarea acestei game de hârtii sunt necesare maşini speciale. Scopul lucrării este analiza celor mai importante caracteristici calitative ale hârtiilor tissue. Sunt discutate masa hârtiei, absorbția apei şi moliciunea, ca cele mai importante caracteristici ale oricărui sortiment de hârtie tissue. Se prezintă şi factorii care influențează rezistența hârtiei. Considerații privind influența factorului de creponare asupra proprietăților hârtiei sunt de asemenea incluse în lucrare.

**Cuvinte cheie:** *Hârtie tissue, Absorbție, Moliciune, Lungime de rupere, Factor de creponare*

**Abstract**

Tissue paper and tissue products differ in a large extent regarding their properties from ordinary paper products. The most valued characteristics are water absorption and softness. These particular properties are optimized by the suitable selecting of raw material and technological profile. Special paper machines are designed to produce this kind of paper. The aim of this paper is to discuss the most important quality requirements of tissue papers. Basis weight, water absorption and softness are discussed as the most important characteristics of any tissue grade. Factors influencing the paper strength are also presented. Some considerations regarding influence of crepe ratio on paper properties are included.

**Keywords**: *Tissue paper, Absorption, Softness, Tensile strength, Crepe ratio*

## 1. INTRODUCTION

The term "tissue" describes products and base paper made from lightweight, dry or wet creped and some “non creped” paper. The properties as water absorbency and paper softness are very important. These products can be made of one or several plies, each ply being of one or several layers, prepared as sheets or rolls, folded or unfolded, embossed or unembossed, with or without lamination, printed or not printed and possibly finished by post treatment, e. g. lotion application. Products of such a kind derive from a single-ply, semi-finished, wet-laid tissue base paper, that is predominantly composed of natural fibres. The origin of fibres may be virgin or recycled or a mixture of both. A typical basis weight of the single-ply tissue base paper ranges from 12 g/m² to 50 g/m².

There is a wide range of products including toilet paper, wipes, kitchen towels, handkerchiefs, facial tissues, household towels, napkins, products for industrial use, etc. Some tissue paper products, in particular kitchen towels and napkins, are sometimes put in contact with food by end users.

Toilet paper is a soft tissue paper product primarily used to maintain personal hygiene after human defecation or urination. It is typically sold

as a long strip of perforated paper wrapped around a cardboard core, to be stored in a dispenser adjacent to a toilet. Most modern toilet paper in the developed world is designed to decompose in septic tanks, whereas some other bathroom and facial tissues are not. Toilet paper can be one-, two- or three-ply, or even thicker, meaning that it is either a single sheet or multiple sheets placed back-to-back to make it thicker, softer, stronger and more absorbent.

The use of paper for such hygiene purposes has been recorded in China in the 6th century, with specifically manufactured toilet paper being mass produced in the 14th century. Modern commercial toilet paper originated in the 19th century, with a patent for roll-based dispensers being made in 1883.

Tissue paper products vary greatly in the distinguishing technical factors: sizes, weights, roughness, softness, chemical residues, "finger-breakthrough" resistance, water-absorption, etc. The larger companies have very detailed, scientific market surveys to determine which marketing sectors require/demand which of the many technical qualities. Modern toilet paper may have a light coating of aloe or lotion or wax worked into the paper to reduce roughness.

Quality is usually determined by the number of plies (stacked sheets), coarseness, and durability. Low grade institutional toilet paper is typically of the lowest grade of paper, has only one or two plies, is very coarse and sometimes contains small amounts of embedded unbleached/unpulped paper. Mid-grade two ply is somewhat textured to provide some softness and is somewhat stronger. Premium toilet paper may have lotion and wax and has two to four plies of very finely pulped paper. If it is marketed as "luxury", it may be quilted or rippled (embossed), perfumed, colored or patterned, medicated (with anti-bacterial chemicals), or treated with perfumes.

Out of the world's estimated production of 23 million tonnes of tissue, Europe produces approximately seven million tonnes. In the CEPI countries was produced 6.87 mil. tone of tissue paper in 2011 [1] The European tissue market is worth approximately 10 billion Euros annually and is growing at a rate of around 3%. The European tissue paper market represents around 23% of the global market. Of the total paper and board market, tissue accounts for 10%. In North America, people are consuming around three times as much tissue as in Europe. In Europe, the tissue paper industry is represented by The European Tissue Symposium (ETS), a trade association [2]. The members of ETS represent the majority of tissue paper producers throughout Europe and about 90% of total European tissue production. ETS was founded in 1971 and is based in Brussels since 1992.

## 2. RAW MATERIALS FOR TISSUE PRODUCTION

As the production of other grades of paper, tissue is made from a stock in which cellulosic fibers are slurried in water. Chemical agents that improve the paper's characteristics can be added in this furnish. The most common of these are wet strength size and tinting dyes to give the desired shade of the paper. The addition of anti-foaming agents and chemicals for pH control make the paper easier to run on the paper machine.

The most important raw material is pulp, originates either from primary fibers or recovered fibers. Virgin fiber pulps produced chemically by sulfate (kraft) and sulfite processes are the best fibrous materials for tissue paper. The resulting paper is strong, absorbent and soft. Softwood pulp has longer fibres and gives the paper strength, whereas hardwood fibers impart softness. Bleached kraft pulps are frequently used in tissue production. Bleached chemithermomechanical pulp (BCTMP) can also be added to the papermaking stock to make the paper more absorbent and bulky.

For economic and environmental reasons, recovered fibers are more and more used for tissue production. There are two main grades of recovered paper: office recovered paper (containing chemical pulp fibers) and mixed recovered paper (containing used newspapers and magazines). Tissue was one of the first paper grades to be made from recovered paper. De-inking and bleaching of recovered paper pulp are compulsory stages for tissue production.

The type of virgin pulp fibres depends on the quality requirements of the tissue. Base paper intented for facial tissue contains mare hardwood pulp for greater softness, while industrial wipes contain more softwood pulp for greater strength. Mix of virgin and recovered fibers are also used, the proportions of primary and secondary fibers also depend on the quality requirements. High-quality tissue products are made from 100 % bleached chemical pulps.

In order to improve the decomposition rate of the paper in septic tanks or drainage, the toilet paper has a lower shorter fibres percentage than facial tissue. The manufacturer tries to reach an optimal balance between rapid decomposition

(which requires shorter fibres) and sturdiness (which requires longer fibres).

Process and functional additives are widely used in tissue production as well. Process additives include: retention aids, wet strength additives, forming additives, biocides, anti-foam agents. Examples of functional additives are: dry strength agents, creping aids, softening agents.

## 3. QUALITY REQUIREMENTS

Each tissue products offer a bundle of properties, but they can be classified according to their prevalent benefit, into the following areas: hygiene/drying and cleaning. The quality requirements of a tissue product include the following parameters: basis weight, water absorbency, softness, bulk, tensile strength, brightness, crepe ratio, appearance. The most important are basis weight, water absorption and softness.

**Basis weight** depends on the end use of the product and ranges between 12 and 50 g/m$^2$. Low basis weights are used in multi-ply products where softness is important (facial tissue, bathroom tissue). Higher basis weights are used in single-ply industrial wipes, which have to be strong. Table 1 shows the basis weight of sanitary paper products [3].

*Table 1 Basis weight of sanitary paper products*

| Product | Basis weight, g/m$^2$ |
|---|---|
| Institutional paper towels-folded | 24-57 |
| Institutional paper towels-kitchen roll | 18-49 |
| Retail paper towels-folded | 24-57 |
| Retail paper towels-kitchen roll | 18-49 |
| Paper napkins | 15-47 |
| Bathroom tissue | 13-36 |
| Facial tissue | 13-31 |
| Toilet seat covers | 13-17 |
| Tray liners | 38-59 |
| Table coverings | 22-32 |

Basis weight (grammage) shall be measured according to TAPPI-T 410 or ISO - 536.

The creping process is considered one of the most critical and sensitive areas in the manufacturing of tissue and towel grades. Optimization of the crepe control process continues to be a delicate balance between increasing production and enhancing sheet quality attributes. In the process of creping, the tissue sheet, which is adhered on to a Yankee dryer surface, is compacted in the machine direction when it comes in contact with a doctor blade to create microfolds. The sheet is then released from the dryer surface and reeled up.

When optimizing the crepe control process it is important to understand the inter relationships among the various process conditions and sheet properties. The sheet properties are changed dramatically during creping as is presented below [4]:

- increased machine direction (MD) sheet stretch (major - up to 800%);
- increased sheet thickness (major - up to 300%);
- increased basis weight (minor – up to 18%);
- reduced sheet density (moderate – up to 38%);
- reduced sheet strength (major – up to 70%)

The key to optimizing the crepe control process is to utilize optimum crepe control chemistry and a sound application approach. A properly designed crepe control chemical program can have a significant impact on improving the stretch to crepe ratio. An increase in the stretch to crepe ratio enables the papermaker to increase machine production, improve converting efficiency and enhance paper water absorption and softness [5].

**Paper thickness** represents a very important parameter that influences the roll diameter of rolled products (kitchen towel) or the stack height of folded products (paper towels). In addition, paper thickness determine paper density and porosity, and, as a consequence, absorption properties and softness of any tissue product [6]. The thickness of tissue paper and tissue products is known to be dependent on the pressure applied to the material at the time of measurement. Several different loading pressures, pressure-foot diameters and loading speeds have been used within the tissue industry. ISO 12625 – part 3 has been prepared by harmonizing those standards applicable to tissue and tissue products currently in use. It specifies a single loading pressure, foot diameter and loading speed to be used for all thickness measurements of tissue and tissue products.

**Absorption** is a basic property of tissue paper that involves the paper's ability to take in and hold water and other fluids. The speed of water absorption and the amount of liquid that a tissue can hold are both considered important aspects of the property of tissue paper absorption. Porosity is another major property of tissue paper and it is closely tied to absorption because it is the pores in tissue paper that absorb fluids.

Tissue products offer an inexpensive and convenient means to pick up a liquid spill and dispose of it. Such products can generally pick up between five and ten times their weight in liquid and hold it without dripping. Tissue accomplishes this remarkable feat by arranging, small (~10 μm wide by 1-3 mm long), hydrophilic (<50 degree contact angle) fibers in a low density structure

(paper porosity >0.8). These fibers give a tremendous surface area per unit volume to hold the fluid (typically > 0.6 $m^2/cm^3$). The ability of tissue to absorb a fluid quickly depends upon having a high capillary pressure to be able to suck the liquid in yet also high permeability to allow the fluid to quickly flow away from the point of insult.

An ideal tissue is a compromise between a large pore structure with high porosity to take in a large volume of liquid rapidly and a micro-fine pore structure that can lift liquids to a large height and retain it against opposing forces. The largest source of porosity in a tissue is from the volume between the tissue and a surface to be wiped, or between plies of a multi-ply tissue. Two tissues stacked together will absorb at a rate more than twice that of one tissue due to the addition of an interface. Similarly, a tissue used to wipe up a spill will absorb the spill much faster when held against a surface than if the spill were poured onto the tissue.

Both water-absorption time (s/cm) and water-absorption capacity (g water/g paper) represent important parameters in the field of comparison of tissue products. The standard ISO 12625-8:2009 describes one principle for determination of water-absorption properties of tissue paper and tissue products, a principle in which sheets of the sample are inserted in a cylindrical basket, which is immersed in water. The results are expressed as water-absorption time and water-absorption capacity. The water-absorption capacity of tissue products ranges 5-11 g/g, [8].

**Softness** is related to the tactile sensation of a person touching a product or a surface of a material. According to ISO 12625-1:2011, the softness characteristic of a tissue product can be divided into bulk softness and surface softness. It has been realized that tissue softness is a complex function of various physical and psychological interactions. Surface softness is the softness perception generated when the consumer gently brushes his fingertips over the tissue surface. Bulk softness is the perception of softness obtained when the tissue sample is crumbled in the hands.

A recent standard proposal – ISO/WD 12625-14/2011 - specifies a method to determine the softness of a tissue paper or a tissue product. The measuring device simulates the human hand and collects the main factors which influence the human hand feel like fibers softness, stiffness and surface structure. The paper softness is calculated form the named values as well as thickness and grammage of paper using mathematical algorithms. The following physical properties are believed to be important factors that affect the tissue paper softness sensation: specific volume and compressibility, modulus of elasticity and surface texture [8].

Specific volume is defined as the volume of unit mass of materials ($cm^3/g$). In the tissue industry, specific volume is often referred to as bulk. It is calculated as the ratio of tissue basis weight to its thickness. Bulk (apparent specific bulk volume) is an important factor contributing to tissue's bulk softness component. If other properties remain same, a bulkier sheet usually generates a higher softness sensation. Since tissue deforms easily under pressure, bulk values vary dramatically with the measurement pressure. Bulk is measured and calculated according to ISO 12625 – part 3. Since low measurement pressure simulates the practical application more realistically, bulk values under low pressures are of more interest. Compressibility is defined as the ratio of the bulk measured at a lower pressure to that at a higher pressure.

**Surface texture** of tissue products plays an important role in human tactile sensation. It is pointed out that a large number of free fiber ends protruding from the tissue surface can simulate the velvety surface of a cloth, which gives customer the sense of surface softness. Stylus profilometry is one of the most commonly used methods to investigate tissue surface texture. The stylus tip scans the tissue surface at a specified speed, and the information of the tissue surface profile is picked up, and then subject to further data processing.

Human Tactile Response-HTR has been developed to quantify the surface softness component, and is defined as the area under the amplitude frequency curve, above the 2.54 □m base line, and between 10 cycles per inch and 50 cycles per inch. A normalizing procedure is taken to adjust the HTR values between 0 and 1. It is suggested that tissue samples with the HTR of less than 0.7 usually give good tactile sensation. However, it is later pointed out that the 0.5mm hemispherical stylus tip.

**Paper strength** is another important property for tissue products. The tissue must functional strength in both dry and wet applications. In the papermaking process, surface tension plays an important role in bringing fibers together. As water is removed, the surface tension generates a tremendous force, which draws the fibers into more intimate contact. The force of surface tension acts in a direction normal to the fiber surface, resulting in a thickness change up to 200%, while the change in area is relatively small. As the web consistency increases, inter- fiber

capillary water is replaced by air, but leaves a film of water around the fibers. Inter-fiber bonding takes place when no free water remains and the associated water of fiber is being removed. It is believed that hydrogen bonding provides inter-fiber bond energy. Experiments show that the energy necessary to rupture the bonds in paper is comparable to the energy liberated from hydrogen bonds formed during paper drying. Table 2 presents the tensile strength of tissue products both in machine direction and cross direction [3, p. 9].

*Table 2 Tensile strength of tissue products: MD-machine direction; CD-cross direction*

| Product | Dry tensile strength, kN/m | | Wet tensile strength, kN/m | |
|---|---|---|---|---|
| | MD | CD | MD | CD |
| Institutional paper towels-folded | 0.92-3.12 | 0.23-1.50 | 0.27 | 0.69 |
| Institutional paper towels-kitchen roll | 0.46-1.50 | 0.11-0.75 | 0.11-0.40 | 0.06-0.23 |
| Retail paper towels-folded | 0.93-3.12 | 0.23-1.50 | 0.27-0.69 | 0.10-0.46 |
| Retail paper towels-kitchen roll | 0.46-1.39 | 0.11-0.74 | 0.11-0.33 | 0,058-0.19 |
| Paper napkins | 0.46-1.27 | 0.26-0.66 | - | - |
| Bathroom tissue | 0.16-1.04 | 0.057-0.52 | - | - |
| Facial tissue | 0.29-0.87 | 0.092-0.29 | 0.017-0.092 | 0.009-0.046 |
| Toilet seat covers | 0.0015-0.11 | 0.0005-0.0015 | - | - |

Table 2 shows that there are important differences between tensile strength in machine direction and in cross direction. Paper strength in cross direction is always lower comparing with MD strength. Tissue papers show an even bigger discrepancy between MD and CD strength, due to the particularity of wet web forming process.

Important factors that affect inter-fiber bonding are fiber length, fibrillation of cellulosic fibers during refining, hemicellulose content and chemical additives.

Fiber length was once considered the most important measure of pulp quality, and is still a property to be considered in papermaking. When the inter-fiber bonding reaches its maximum for unit length, the strength of inter-fiber bonding parts depends on the length of its fibers. Longer fiber has less chance of slippage between the fibers when the paper is subject to stress. In addition, the probability of fibril formation is higher for longer fibers, which leads to higher capacity for inter-fiber bonding.

The primary wall of a fiber is a deterrent to fiber bonding. With mechanical treatment, such as refining, the primary wall is removed, and the fibrils from the secondary wall are caused to stick out from the fiber surfaces. As a result of fibrillation, the effect area for the inter-fiber bonding is increased and the fiber becomes less rigid. The surface tension is increased significantly due to the raised surface elements and tends to bring the fine fibrils into contact. The finer fibrils lie in parallel contact, and are joined by hydrogen bonding when the water is removed. Therefore the dry strength of paper is increased by fibrillation under most conditions.

The importance of hemicelluloses in paper strength development is well recognized, and is believed to play a more important role than fibrillation. When the fiber structure is loosened, additional water is more easily attracted by the large surface of the amorphous, hydrophilic hemicelluloses material. In comparison, the cellulose is hydrophilic itself by nature, though part of it is crystalline and not available for hydration. Therefore, hemicelluloses contribute strongly to swelling. Furthermore, the carboxyl groups on xylan glucuronic acid groups are identified to be the main source of negative fiber surface charge.

Most chemical additives used in the paper industry carry cationic charges and can adsorb onto pulp fiber surface through the electrostatic mechanism. The additives not only change the amount of bonding between adjacent fibers, but also modify the strength of the individual bond. Usually, the additives have a minimal effect on the intrinsic fiber strength. In the low basis weight paper, such as tissue, the inter-fiber bonding plays a much more significant role than the fiber strength.

**Colored** toilet paper in colors such as pink, lavender, light blue, light green, purple, green, and light yellow (so that one could choose a color of toilet paper that matched or complemented the color of one's bathroom) is

usually use. Today, in the United States, plain unpatterned colored toilet paper has been mostly replaced by patterned toilet paper, normally white, with embossed decorative patterns or designs in various colors and different sizes depending on the brand. Colored toilet paper still remains commonly available in many European countries.

## 4. CONCLUSIONS

The quality requirements of a tissue product include basis weight, water absorbency, softness, bulk, tensile strength, brightness, crepe ratio, appearance. The most important are basis weight, water absorption and softness.

Absorption is a basic property of tissue paper that involves the paper's ability to take in and hold water and other fluids. The speed of water absorption and the amount of liquid that a tissue can hold are both considered important aspects of the property of tissue paper absorption. Absorption depends on many factors: basis weight, paper thickness, porosity, cellulosic fibers properties, crepe ratio, etc.

Softness represents the tactile sensation of a person touching a tissue product and can be divided into bulk softness and surface softness. Recently, the paper softness can be calculated form the named values as well as thickness and grammage of paper using mathematical algorithms. The following physical properties are important factors that affect the tissue paper softness sensation: specific volume and compressibility, modulus of elasticity and surface texture.

Among mechanical properties of a tissue paper, tensile strength is of particular importance. There are important differences between tensile strength in machine direction and in cross direction. Paper strength in cross direction is always lower comparing with machine direction strength. If is compared with ordinary paper grades, tissue papers show a bigger discrepancy between machine direction and cross direction strength, due to the particularity of wet web forming process.

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# THE IDENTIFYING OF THE PAPER AND BOARD FIBROUS COMPOSITION BY USING COLOR REACTIONS

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**Rezumat**

Analiza microscopică cu ajutorul reacțiilor de culoare este o metodă de identificare a compozitiei fibroase a unui produs papetar. Determinarea acesteia reprezintă identificarea componentelor fibroase din probele de hârtie, carton şi celuloză, ținând cont de originea fibrelor şi de metoda de fabricare. Pentru stabilirea compoziției materialului fibros din care sunt fabricate hârtiile, porțiuni prelevate din acestea se prepară sub formă de suspensii fibroase, apoi sunt tratate cu reactivi de culoare (reactiv Graff C, reactive Herzberg) şi analizate la microscop.

**Cuvinte cheie:** *Compoziție fibroasă; Reacții de culoare; Analize microscopice*

**Abstract**

The microscopically analysis based on color reactions is an identification method of the fibrous composition for a paper product. It's determination represents the identifying of the fibrous components of the paper, board and pulp samples, taking into account the origin of the fibers as well as the method of production.
For determining the composition of fibrous material from which are made papers, portions taken from these prepared of fibrous suspensions, and are treated with color reagents (reagent Graff C, reagent Herzberg) and analyzed under a microscope.

**Keywords:** *Fibrous composition; Color reactions; Microscopic analyses*

## INTRODUCTION

The fibrous composition of paper is characteristic to any paper assortment. It's determination represents the identifying of the fibrous components of the paper, board and pulp trials, taking into account the origin of the fibers as well as the method of production. The analysis of the fibrous composition can be either qualitative or quantitative. The qualitative microscopically analysis of the fiber semi products and of the finite products from the pulp and paper industry helps identifying the fibrous composition with the help color
reactions and also by identifying the nature of the fibrous material with the help of its morphological characteristics. The quantitative microscopically analysis helps to determine the anatomic elements' dimensions of the mass ratio for different semi products.

## TECHNICS FOR IDENTIFCATION THE FIBROUS COMPOSITION OF PAPER

### The weight factor using

To determine the anatomical dimensions a ocular micrometer (with a 50 division micrometric scale) and an objective micrometer(with a 100 division micrometric scale) can be used. The linear mass of a fiber (c), represents the medium mass (dried) per length unit for a particular type if fiber, generally expressed by mg/m. The weight factor (f) is expressed as proportion between the linear mass of a fiber of a particular type and the linear mass of a reference fiber. Generally, the

reference fiber is the cotton fiber. The weight factor was fixed at a value of 1,00 and the linear mass of a fiber was determined as being 0,180 mg/m for the cotton fiber. The weight factor for a type of fiber can result from its linear mass by using the following equation:

$$f = c/0,180 \qquad [1]$$

where :
f = weight factor and
c = fiber linear mass , mg/m

The weight factor varies based on the type of fiber and the manner in which the pulp was fabricated; a weight factor must be determined for every fiber type present in the analysed material. In the event that such a determination is impossible, the standard values indicated in table 1 can be used.[2]

*Table 1 Weight factors*

| FIBRE ORIGIN | WEIGHT FACTORS |
|---|---|
| Cotton fibers | 1,0 |
| White softwood chemical pulp | 0,9 |
| Softwood dissolving pulp | 0,85 |
| Softwood semichemical bisulfate Cellulose | 1,4 |
| Sawdust wood pulp | 1,3 |
| Thermo-mechanic pulp | 1,7 |
| Softwood chemical mechanic pulp | 2,0 |
| Hardwood chemical pulp (birch, poplar, beech) | 0,5 |
| Hardwood chemical pulp (maple, willow) | 0,4 |
| Hardwood semi chemical pulp – birch | 0,9 |
| Hardwood mechanical pulp | 0,9 |
| Cotton waste | 1,25 |
| Straw pulp for board | 0,6 |
| Bleached straw pulp | 0,35 |
| Bamboo pulp | 0,55 |
| Flax pulp | 0,8 |

**The microscopically determination of the fibrous composition**

The mass proportion of the different fibrous semi products of the finite product is determined as it follows: the microscopically compound is viewed on fields that lay on four or five transversal tapes, always starting from one of the corners of the compound; after that the elements that belong to each type of fibrous semi product (differenced in the compound through color) are counted and added separately to the visual fields. Following this, the lengths of all the elements that belong to a certain type of fibrous semi product from all the fields are put together; then we multiply the results value with the value of a single division of the ocular micrometer with which the measuring took place(value expressed in millimeters) thus obtaining the value of the length expressed in millimeters for the elements in certain fibrous paste. To express the mass proportion, you then multiply this value with the weight factor of the fibrous paste. The results obtained in these calculations are then expressed as mass percentages for the different fibrous semi products, referred to the total composition of the trial. [3]

Determining the fibrous composition is done using a microscope to see a small quantity of representative fibers from the test specimen analysed after it having been colored with coloring reactives:

- ***qualitatively,*** based on the obtained colorations and the fiber morphological characteristics;
- ***quantitatively***, by counting the crossing points of the different fiber types with the counting line and the conversion of the obtained data into mass percentages with the help of appropriate weight factors. [4]

The main steps in determining the fibrous composition of paper and board:

1. the preparation of the sample, which differs based on the paper category to which they belong;
2. the coloring and the preparation of the support fin plate. The method used to color and prepare the fin plates differs based on the used reactive. The adequate reactive is picked with the help of the coloring guide, and the fiber color is done either on the blade or in a test tube.[5]

**Coloring using the Herzberg reactive**

The Hertzberg reactive is a mixture of zinc, iodine solution and water. This reactive is tested on cotton fibers which, after being colored with the Hertzberg reactive must turn dark-red. A bluefish shade shows us that the solution is too concentrated and that it must be diluted with a very little water.

The fibers of a chemical pulp must acquire a violet-blue color. A shade of red will show us that there is too little zinc chloride in the compound, mistake that can easily be fixed by adding a few crystals of zinc chloride. The coloring of the fibers takes place by adding two or three drops of Herzberg dye over the fibrous compound previously prepared. The colored support blade is put on the microscope plate, after which the fibers are counted and identified.

*Table 2 Colors obtained using the Herzberg reactive*

| Fiber or pulp type | Color |
|---|---|
| Chemical pulp (wood, straw, alfa) | Blue ,violet-blue |
| Mechanical pulp (wood, straw, jute) | Yellow |
| Rag pulp (cotton, flax, hemp) | dark red |
| Semi chemical and mechanical-chemical pulp | Faded blue, faded yellow, mottled blue and yellow |
| Regenerated pulp fibers (rayon) | Dark blue-violet |
| Cellulose acetate fibers | Yellow |
| Synthetic fibers | Ranging from colorless to dark ochre |

The microscopically aspect of cotton pulp fibers, softwood pulp fibers, hardwood pulp fibers, coated board with 3 layers -front layer – F, middle layer – m and back layer – S-(all these were colored with Herzberg reactive) was studied.[4]

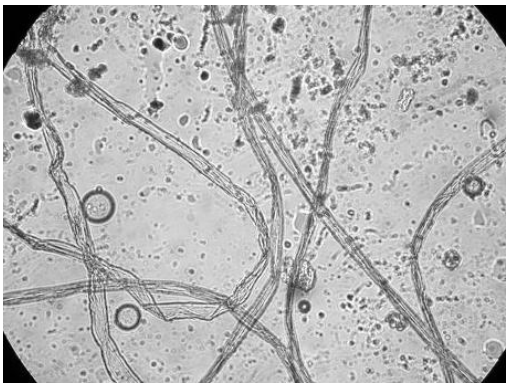

*Fig.1 The microscopic aspect of cotton pulp fibers colored with Herzberg reactive in bordo-red*

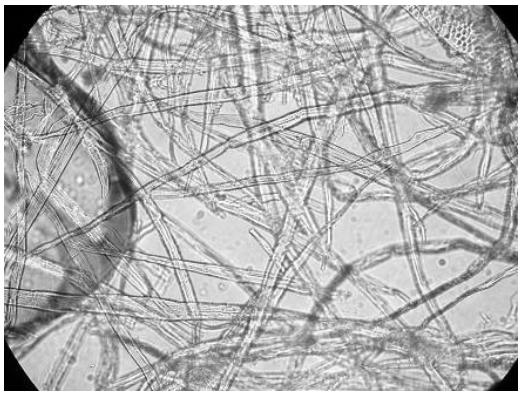

*Fig.2 The microscopic aspect of hardwood bleached kraft pulp colored with the Herzberg reactive*

*Fig.3 The microscopic aspect of softwood bleached kraft pulp*

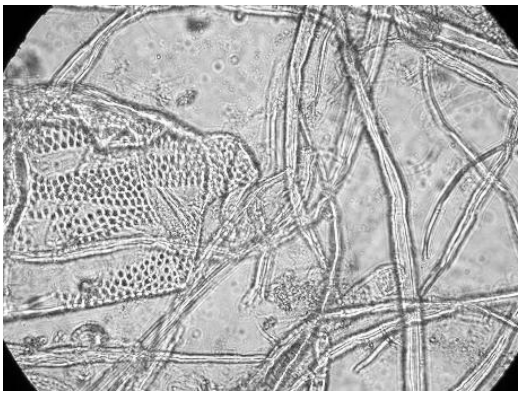

*Fig.4 The microscopic aspect of the front layer fibers*

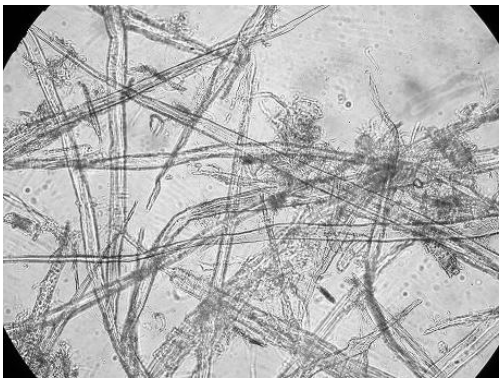

*Fig.5 The microscopic aspect of board middle layer fibers*

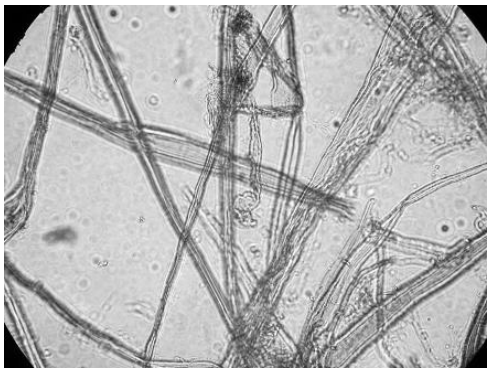

*Fig.6 The microscopic aspect of board back layer fibers*

## Graff „C" reactive coloring

The application domain of the Graff „C" reactive is a well-developed one, it allows for the most complete discrimination of a fibrous material. Still, it is based on a very fine discrimination of dyes and of the intensity of the resulted colors.
Practically, the main uses of the Graff „C" reactive are:
a) the discrimination between the chemical, semi chemical and mechanical types of cellulose
b) the discrimination between the softwood sulfate pulp and the white sulfite pulp. Generally, the difference in tinge is enough to allow for the counting of the fibers.
c) the discrimination between hardwood sulfate pulp and white hardwood sulfite pulp. The difference in tinge is more evident in the case of non-bleached types of pulp.
d) the discrimination between the softwood pulp and the hardwood pulp with the exception of chemical transformation pulp. Wythe the sulfate types of pulp, the difference in tinge is enough; in the case of by sulfite types of pulp, the difference is less obvious yet still obvious enough in most cases to allow for the counting of the fibers.
e) the discrimination between straws and alpha in the case of bleached softwood types of pulp. The difference in color is obvious.
The Graff „C" reactive is a mixture of aluminum chloride solution, calcium chloride solution, zinc chloride solution and iodine solution. With the reactive prepared as such, the analyzed fibers have been colored with two – three drops of the Graf „C" reactive after which they have been microscopically analyzed thus identifying the fibers the the colors they have taken after having applied the reactive (as depicted in table no. 2).

*Table 2 Colors obtained using the Graff „C"reactive*

| TYPES OF CELLULOSE | COLOR |
|---|---|
| Softwood chemical pulp | |
| Unbleached sulfate | Shades of yellow and brown |
| Bleached sulfate | Grey light blue or light grey |
| Chemical transformation sulfate | Brown vermillion |
| Unbleached bisulfate | Shades of yellow |
| Bleached by sulfite | Light brown |
| Chemical transformation bysulfite | Light brown or light red |
| Hardwood chemical pulp | |
| Unbleached sulfate | Dark grey – light blue- blue |
| Bleached sulfate | Dark blue |
| Chemical transformation sulfate | Blue vermillion |
| Unbleached by sulfite | Grayish yellow |
| Bleached by sulfite | Light – blue or bluish grey |
| Chemical transformation by sulfite | Light brown |
| Semi chemical pulp made from softwood | Lively yellow |
| Unbleached hardwood | Different shades of green |
| Bleached hardwood | Dark blue |
| Mechanical cellulose | Lively yellow |
| Unbleached straw and alfa chemical pulp | Greenish blue |
| Bleached | Light-blue grey, violet blue |
| Cotton cellulose | Bordo(dark red) or brick-colored |

*Fig.7 The microscopic aspect of cotton paste fibers*

Note: the presence of the cotton fibers can be recognized from the flat, long, twisted and with no other accompanying elements fiber aspect.

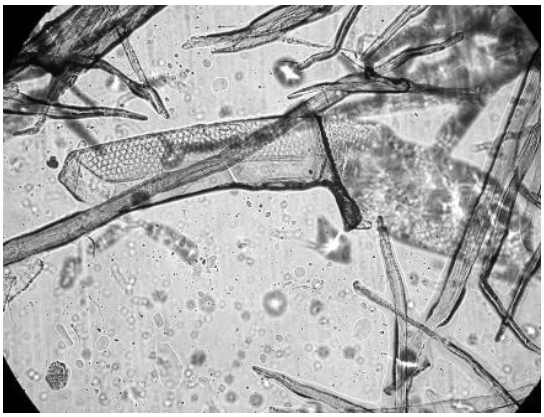

*Fig.8 The microscopic aspect of hardwood bleached sulphate pulp fibers – they tend to get shades of blue and light-blue*

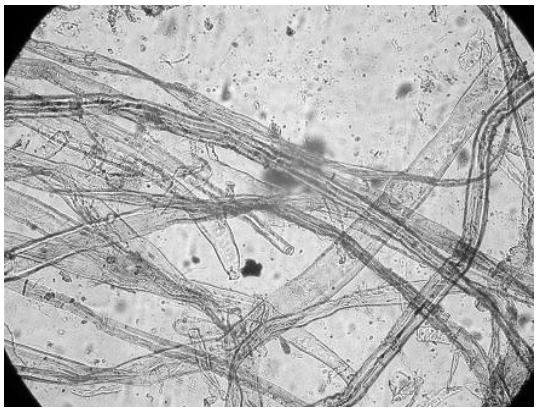

*Fig.9 The microscopic aspect of softwod bleached sulfate cellulose fibers*

*Fig.10 The microscopic aspect of front layer of fibers(coated layer)*
*(Hardwood bleached sulfate chemical cellulose)*

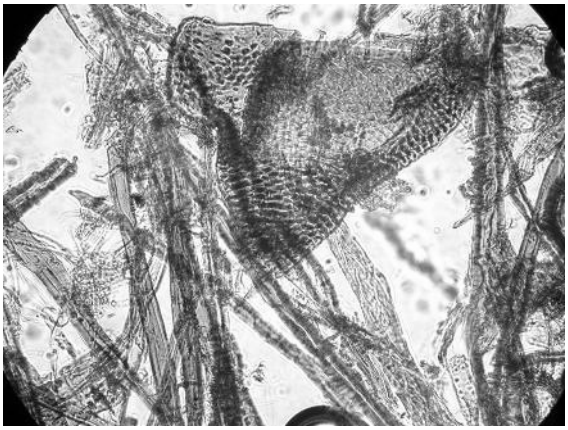

*Fig.11 The microscopic aspect of board middle layer fibers (Mechanical pulp)*

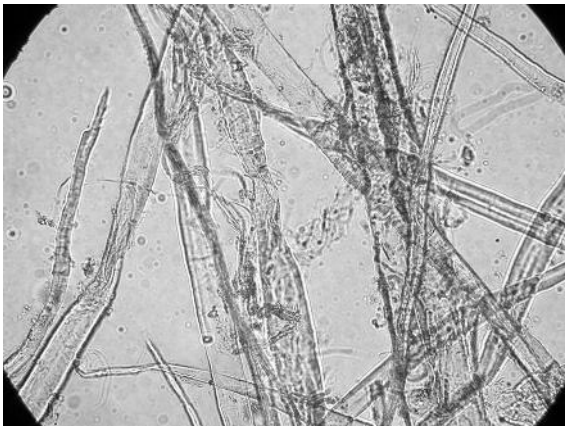

*Fig.12 - The microscopic aspect of board back layer fibers ( Sulphate chemical cellulose)*

## CONCLUSIONS

To conclude, the microscopically analysis of the fibrous composition of paper done with the help of color reactions represent an identification method for a paper product. Thus, the fibrous composition examination can also be used in the case of support paper for valuable documents of bank notes which are suspected of being fraudulent. The cotton, the silk and the textile fibers are frequently used to produce valuable document support paper. Aside from these pastes, filling materials will also be identified in the paper composition, which will insure the role of the component fiber, bleaches, special oils are other securing elements binding agent. The morphological analysis of the suspicious documents and bank notes is done with the naked eye first, then by using a microscope. To establish the composition of the fibrous material from which the paper is made, which acts as the trial support, test portions are prepared in the shape of fibrous suspensions and are treated with color reactive (Graff C reactive, Herzberg reactive) and analyzed under a microscope.

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# WATER FOOTPRINT OF PAPERS FOR CORRUGATED BOARD – A COMPARISON

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**Abstract**

In this paper, the water footprints of some of the most used papers for corrugated board are accounted. The procedure for calculation of water footprint of paper is also discussed. The values of water footprint of paper are very different depending of paper grade, paper composition and technological level of the paper mill. Testliner shows a considerable lower value of water footprint, comparing with krafliner. This study shows that the green water footprint has the highest contribution to the total water footprint of paper, due to the contribution of wood used in pulp production. The contribution of the blue and grey water footprints is smaller and consists of the water that is lost by evaporation during the production process and of the water lost as mill effluent. The paper shows that the use of recovered paper is particularly effective in reducing water footprints of paper products.

**Key Words:** *Water Footprint, Kraftliner, Testliner, Water Managament, Sustainability*

**Rezumat**

În lucrare se determină amprentele ecologice de apă ale unora dintre cele mai utilizate hârtii pentru fabricarea cartonului ondulat. Se discută şi metoda de calculare a amprentei de apă a hârtiei. Valorile amprentei de apă sunt foarte diferite şi depind de sortimentul hârtiei, de compoziția fibroasă şi de nivelul tehnologic al fabricii. Hârtia testliner are amprenta de apă mult inferioară hârtiei kraftliner. În lucrare se arată că amprenta apei verzi are cea mai mare contribuție la amprenta totală de apă a hârtiei datorită contribuției lemnului utilizat la obținerea celulozei. Contribuția amprentelor de apă albastră şi gri este mai mică şi constă din apa pierdută prin evaporare şi din apa conținută de efluentul fabricii. Lucrarea arată că folosirea maculaturii este deosebit de utilă pentru reducerea amprentei de apă a hârtiei.

**Cuvinte cheie:** *Amprenta de apă, Krafliner,Testliner, Managementul apei, Dezvoltare durabilă*

## INTRODUCTION

Water footprint is defined as the total volume of freshwater used to produce the goods and services consumed by a person or a community [1]. The water footprint is an indicator of freshwater use that looks not only at direct water use of a consumer or producer, but also at the indirect water use. The water footprint can be regarded as a comprehensive indicator of freshwater resources appropriation, next to the traditional and restricted measure of water withdrawal. A water footprint can be calculated for a particular product, for any well-defined group of consumers (e.g. an individual, family, village, city, province, state or nation) or producers (e.g. a public organization, private enterprise or economic sector). The water footprint is a geographically explicit indicator, not only showing volumes of water use and pollution, but also the locations.

The components of a water footprint include the blue, green and grey water footprints [2]. For paper products, the water footprint can be

accounted according to *The Water Footprint Assessment Manual*, edited by Hoekstra et al. [3]. Water footprint of paper for corrugated board, taking into account country-specific recovered paper utilization rates, ranges between 400-2000 $m^3$/t. Water footprint of newsprint ranges between 200-1500 $m^3$/t and of printing and writing paper between 300-2600 $m^3$/t. [4].

The goals of this paper are to present the steps for accounting the water footprint account of paper and to compare the water footprints of two main paper grades used for corrugated board manufacture.

## EVALUATION OF WATER FOOTPRINT OF PAPERS FOR CORRUGATED BOARD

The water footprint of paper is defined as the total volume of fresh water that is used directly or indirectly to produce the product. It is estimated by considering water consumption and pollution in all steps of the manufacturing chain. The accounting procedure is similar to all grades, either paper is based on virgin cellulosic fibers or on recovered paper. The water footprint is the sum of green, blue and grey component.

Two main grades of paperboard are considered for footprint evaluation in this paper: kraftliner made from 100% unbleached softwood kraft pulp and testliner based of 100 % recovered paper. These paper grades are produced in paper mills in Romania, on dedicated paper machines. The water footprint was calculated in both cases for the production of 1 ton of paper. Some aspects were taken into consideration regarding water footprint accounting:

- the main raw material inputs selected are unbleached kraft pulp, recovered paper and starch;
- softwood kraft pulp is imported from Scandinavia, due to the fact that currently Romania is not a producer of chemical pulp; recovered paper comes from domestic production;
- water contained by paper as moisture was taken into consideration;
- electrical energy and natural gas, although these are not direct material inputs to paper itself, these are important energy inputs to the operational side of paper production; data regarding the water footprint of these inputs were adopted from literature;
- labor and transport were excluded from the water footprint assessment, as they are expected to have a minor contribution to the overall water footprint of a paper product;
- thermal pollution with used water was excluded from the grey water footprint assessment.

Water footprint of paper, $WF_p$, accounts as the sum of green water footprint, $WF_{green}$, blue water footprint $WF_{blue}$, and grey water footprint $W_{.grey}$, according to the equation (1):

$$WF_p = WF_{green} + WF_{blue} + WF_{grey}\ ,\ \text{m}^3\ /\text{t of paper} \qquad (1)$$

## GREEN WATER FOOTPRINT

Green water footprint, $WF_{green}$, of paper mainly refers to rainwater that is evaporated during tree growth, and can be determined using the equation (2) [3].

$$WF_{green} = \left(\frac{ET_a + (Y_{wood} + f_{water})}{Y_{wood}}\right) \times f_{paper} \times f_{value} \times \left(1 - f_{recycling}\right), m^3 \qquad (2)$$

- $ET_a$ is the evapotranspiration from a forest/woodland ($m^3$/ha.year);
- $Y_{wood}$ is the wood yield from a forest/woodland ($m^3$/ha.year);
- $f_{water}$ is the volumetric fraction of water in freshly harvested wood ($m^3/m^3$);
- $f_{paper}$ the wood-to-paper conversion factor (i.e. the harvested volume needed to produce a metric ton of paper product - $m^3$/ton);
- $f_{value}$ the fraction of total value of the forest which is associated with paper production (dimensionless);
- $f_{recycling}$ the fraction of pulp derived from recovered paper (dimensionless).

Equation (2) shows that the green water footprint mainly depends on the forest evapotranspiration rate, $ET_a$, which largely differs among vegetation areas. The water data for Scandinavian forests (softwood - spruce) are exemplified in table 1 [5].

*Table 1 Example of boreal forest water data for softwood.*

| Forest water data | Forest evapotranspiration, ($ET_a$) $m^3$/ha.year | Wood yield, ($Y_{wood}$) $m^3$/ha.year | Volumetric fraction of water ($f_{water}$) $m^3$ water/$m^3$ wood |
|---|---|---|---|
| Softwood (spruce) | 1689 | 7 | 0.53 |

The values for wood-to-paper conversion factor, $f_{paper}$ are listed in table 2.

*Table 2 Wood-to-paper conversion factor*

| Product | Wood-to-paper conversion factor, $f_{paper}$ $m^3$/t |
|---|---|
| Mechanical pulp | 2.50 |
| Semi-chemical pulp | 2.67 |
| Chemical pulp | 4.49 |
| Dissolving pulp | 5.65 |
| Recovered paper | 0 |
| Newsprint | 2.87 |
| Printing & Writing paper | 3.51 |
| Other paper and board | 3.29 |

As regarding the fraction of total value of the forest which is associated with paper production, $f_{value}$, it is assumed that paper is produced from forests that have wood production as the primary function and for which annual growth is equal to annual harvest, so we assume the value fraction to be equal to unit, ($f_{value}$ = 1).

*Table 3. Values of the components of green water footprint of the paper grades, $m^3$/t of paper*

| Component of green water footprint | Paper grade | |
|---|---|---|
| | Kraftliner | Testliner |
| $ET_a$ | 1689 | 0 |
| $Y_{wood}$ | 7.0 | 0 |
| $f_{water}$ | 0.53 | 0 |
| $f_{paper}$ | 4.49 | 0 |
| $f_{value}$ | 1 | 0 |
| $f_{recycling}$ | 0 | 1 |
| Green water footprint, $WF_{green}$, (Eq. 2), $m^3$/t | 1088.2 | 0 |

Table 3 shows that the use of recovered paper may be particularly valuable in reducing water footprints of paper products, due to the fact that pulp obtained from recovered paper has no forestry-related water footprint (green water footprint is zero). Water footprint of paper grades based on recovered paper are much lower comparing with those containing chemical pulps. In addition, the global water footprint of paper can be reduced by choosing pulp grades, production sites and wood species that are more water-efficient.

The value of fraction of pulp derived from recovered paper, $f_{recycling}$, is zero for kraftliner (that is made from 100 % chemical pulp) and 1 for testliner, made 100 % from recovered paper. The values of the components of green water footprint of the paper grades included in this study are listed in table 3.

## BLUE WATER FOOTPRINT

Blue water footprint, $WF_{blue}$, refers to freshwater withdrawn from rivers, lakes or groundwater reservoirs that is used in paper production which does not return to the place of origin during the same period of time, either because it is evaporated, incorporated into the product, transferred to another basin or returned later on. Blue water footprint has to be calculated by assessing the water flows of the paper mills and that of externally produced starch, additives, pigments etc. The blue water footprint includes:

1. Water that evaporates in the drying section of paper machine, (*Blue Water Evaporation*);
2. Water stored in the paper product and water footprint of chemicals and energy, (*Blue Water Incorporation*);
3. Water in the effluent sludge that is a by-product from the used water treatment plant and other losses including water leakage and water that are not returned to the same catchments area, (*Lost Return Flow*).

Blue water footprint is calculated according to the equation (3) [3].

$$WF_{blue} = \text{Blue Water Evaporation} + \text{Blue Water Incorporation} + \text{Lost Return Flow}, \ m^3 \quad (3)$$

*Blue Water Evaporation* depends on the dryness of paper web entering in the dry section of the paper machine and on the paper moisture at reel. We assume an average of 45 % dryness of paper web that enters in the dry section and 7 % paper moisture at reel for both paper grades. In this situation, 750 L (0.75 $m^3$) of water evaporates per tone of paper in the dry section.

*Blue Water Incorporation* includes, at list: water stored in paper, water footprint of starch and additives used in papermaking, purchased electricity and fuel. There are difficulties to account these contributions due to the lack of literature data and to the particularities of the paper machines. Most of the components must be approximate using mills experience and related literature. For example, specific starch and additive consumptions may differ even at the same paper grade, according to basis weight of paper and required strength properties. The electric energy consumption depends on paper grades: kraftliner consumes considerable much energy that tesliner, due to refining of kraft pulp. We consider that the steam for the paper mill is produced using natural gas as primary energy carrier. The energy consumption depends also on the season: during winter time, the specific energy consumption is 10-20 % higher. For these reasons, the specific consumptions of materials and energy for both paper grades were adopted as average values from literature. Table 4 shows the materials and energy specific consumptions for an integrated kraftliner paper mill (fibreline included) and a tesliner paper mill (plant for recovered paper processing included) [6]. We assume 7 % moisture at reel of both paper grades.

*Table 4. Materials and energy specific consumptions*

| Materials and energy specific consumption* | Paper grade | |
|---|---|---|
| | Kraftliner | Testliner |
| Water (industrial and process water), $m^3$/t | 10 | 7 |
| Chemicals, Starch, kg/t | 30 | 60 |
| Electrical energy, kWh/t | 1300 | 700 |
| Thermal energy, GJ/t | 16.0 | 9.0 |
| Fuel, (conventional fuel), t. | 0.6 | 0.4 |

* *pulp production (kraftliner) and recovered paper processing (testliner) included*

Based on the figures from table 4, the components of *Blue Water Incorporation* were determined according to [7] and are included in table 5.

*Table 5. Components of Blue Water Incorporation*

| Component of blue water incorporation | Paper grade | |
|---|---|---|
| | Kraftliner | Testliner |
| Water stored in paper, $m^3$/t | 0.070 | 0.070 |
| Water footprints ($m^3$/t): | 0.050 | 0.10 |
| Chemicals, starch | 260 | 140 |
| Electrical energy | 180 | 100 |
| Thermal energy | 70 | 50 |
| Fuel | | |
| *Blue Water Incorporation* $m^3$/t | 510.12 | 290.17 |

*Lost Return Flow* includes effluent sludge generated during used water treatment and other water losses that are not returned to the same catchments area. The main contributor to *Lost Return Flown* is water included in the sludge. The sludge generation mainly depends on the feedstock used for paper production. If recovered paper is used, the quantity of sludge is significantly higher if compare with using chemical pulp. The sludge specific generation depends on the sort of recovered paper, on contamination degree of recovered paper and on the processing plant performance. Mill practice shows that in producing testliner, an average of 30 kg of sludge (a.d.) per ton of paper is generated [8]. As regarding kraftliner, the quantity of sludge is considerable lower, around 10 kg/t of paper. If suppose the moisture of sludge 50 %, the water lost with sludge represents 30 kg for testliner and 10 kg for kraftliner. No other water losses were taken into consideration for *Lost Return Flow* accounting.

## GREY WATER FOOTPRINT

While blue and green water footprint indicates a consumption of a resource, grey water footprint is an indicator of pollution. Grey water footprint is the volume of freshwater needed to assimilate a given load of pollutants on reaching freshwater sources (for example a production process effluent discharged to a receiving water body), based on natural background concentrations and existing ambient water quality standards. As a rule, for grey water footprint calculation, the equation (4) is used [3].

$$WF_{grey} = \frac{L}{C_{max} - C_{nat}} = \frac{Effl \times C_{effl} - Abstr \times C_{act}}{C_{max} - C_{nat}}, m^3 \quad (4)$$

– $L$ : additional pollutant load contained in the receiving water body, mass/time;
– *Effl* : effluent volumetric flow rate, volume in time;
– *Abstr* :volumetric flow rate of the abstraction, volume in time;
– $C_{effl}$ : actual concentration of the effluent, mass/volume;
– $C_{act}$ : actual concentration of the intake water, mass/volume;
– $C_{nat}$ : the natural concentration of the pollutant in the receiving water body (river, lake etc.). For human-made substances that naturally do not occur in water $C_{nat} = 0$;
– $C_{max}$ : ambient water quality standard, mass/volume

The emission load includes measures of chemical oxygen demand (COD), biological oxygen demand (BOD), absorbable organic halogens (AOX), total organic carbon (TOC), ammonium, chlorides, phosphates and nitrates. Data on *Effl* , *Abstr* and *Cact* come from the mill own databases and data on $C_{nat}$ and $C_{max}$ are usually obtained via the local environmental authorities. Theoretically, the grey water footprint can be zero if effluent volume is entirely reused in the paper mill. However, paper mills consume large quantities of industrial and process water that, at the end of the process, are partially removed as effluent. The effluent flow strongly depends on the specific water consumption in producing chemical pulp, recovered paper pulp and for papermaking. Accounting of grey water footprint according to equation (4) is not a simple task. It's simpler to determine the effluent flow generated by the water treatment plant. The mill practice shows volumes of effluent between 1.5 and 10 $m^3$/t of paper, [8]. In these circumstances, we assume a specific effluent flow of 7 $m^3$/t, both for kraftliner and testliner. The water footprint values of the papers investigated in this work are presented in table 6.

*Table 6 Water footprint structure and quantification*

| Water footprint structure | Paper grade | |
|---|---|---|
| | Kraftliner | Testliner |
| Green water footprint, $m^3$/t | 1088.2 | 0 |
| Blue water footprint, $m^3$/t | | |
| *Blue Water Evaporation* | 0.75 | 0.75 |
| *Blue Water Incorporation* | 510.12 | 290.17 |
| *Lost Return Flow* | 7 | 7 |
| Grey Water Footprint, $m^3$/t | 7 | 7 |
| Water footprint, $m^3$/t | 1613.07 | 304.92 |

Table 6 shows that the values of water footprint of paper are very different depending of paper grade, paper composition and technological level of the pulp and paper mill. Green water footprint has the highest contribution to the total water footprint of paper, due to the contribution of wood used in pulp production. For paper made from recovered paper, the green water footprint is zero, due to the absence of wood as raw material. The contribution of the blue water footprint of paper is also important due to the high energy consumption. In our example, the results show that the water footprint of testliner is 5 times lower than that of kraftliner. This result represents a strong argument in using recovered paper in papermaking, in accordance with the principles of sustainable development.

## CONCLUSIONS

The water footprint of a paper product is the sum of the blue, green and grey water footprints. There are methods that allow the calculation of the water footprint of paper by determining the values of the footprint components. The values of water footprint of paper are very different depending of paper grade, paper composition and technological level of the paper mill.

Green water footprint has the highest contribution to the total water footprint of paper, due to the contribution of the wood used in pulp production. For paper made from recovered paper, the green water footprint is zero, due to the absence of wood as raw material. The water footprint of testliner is 5 times lower than that of kraftliner.

The global water footprint of paper can be reduced by choosing pulp grades, production sites and wood species that are more water-efficient. Water footprint of paper grades based on recovered paper is much lower compared with those containing chemical pulps.

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PROIECTE DE CERCETARE

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UEFISCDI

INOVARE SI CREATIVITATE

Cercetare socio-economica si umanista

# Paphercon: Developing Non-conventional Materials and Plasma Technique for Sustainable Solutions in Paper Heritage Conservation"

# Dezvoltarea de materiale neconvenționale şi a unei tehnici de tratament în plasmă rece pentru soluții sustenabile în conservarea patrimoniului pe suport de hârtie

## Oportunitatea şi conceptul proiectului

Îmbătrânirea naturală a documentelor pe suport papetar din arhive şi biblioteci este responsabilă pentru pierderi imense ale patrimoniului documentar. Conservarea şi restaurarea documentelor pe suport papetar se referă la ansamblul operațiilor ce au ca scop prelungirea duratei lor de viață, prin protejarea față de factorii de degradare sau prin remedierea degradărilor pe care acestea le-au suferit. Finalitatea operațiilor de conservare o constituie salvarea integrității fizice şi funcționale a documentelor.

Metodele de conservare includ tratamente curative şi de restaurare (dezinfecția, curățirea umedă, dezacidificarea şi tratamente de suprafață cu materiale de consolidare) care implică interacțiuni complexe intre suportul papetar şi alte materiale ale obiectului de patrimoniu (cerneluri, vopsele, coloranți, etc.). Cercetările în acest domeniu s-au intensificat în ultimele decenii, majoritatea fiind concentrate spre găsirea celor mai eficiente metode de dezacidificare şi spre identificarea unor noi materiale pentru tratamente de consolidare. Cu toate acestea, în prezent multe din metodele aplicate continuă să fie empirice şi nu se bazează pe cunoaşterea în profunzime a interacțiunilor dintre suportul papetar şi diferiți factori implicați în tratamentele de curățire şi restaurare. Aceste abordări conduc adesea la eficiențe nesatisfăcătoare ale operațiilor de conservare sau chiar la distrugerea şi pierderea unor documente de patrimoniu. De asemenea, de cele mai multe ori tratamentele curative şi cele de restaurare sunt realizate ca operații complet independente, fără un control al interdependențelor dintre ele.

În acest context, proiectul Paphercon are ca *obiectiv general*: dezvoltarea, implementarea şi validarea unei metode integrate de conservare sustenabilă a documentelor pe suport papetar.

*Conceptul proiectului* constă în cuplarea tratamentului în plasmă rece de înaltă frecvență (HF), ca soluție ne-invazivă de curățire fizică şi decontaminare biologică, cu aplicarea la suprafața hârtiei a unor filme pe bază de derivați de chitosan

multifuncționali, ca materiale ecologice de consolidare care conferă şi proprietăți de barieră la umiditate şi la atacul microbian. Pe tot parcursul derulării proiectului, se va acorda o atenție particulară introducerii unor instrumente şi procedee ştiințifice pentru monitorizarea şi controlul eficienței şi durabilității tratamentelor de conservare.

## Strategia de cercetare

Strategia tehnico-ştiințifică propusă în planul de realizare a proiectului include patru etape succesive, cu obiective şi activități specifice care să conducă la îndeplinirea obiectivului general al proiectului.

**Etapa I** (2012): *Dezvoltarea protocolului de cercetare. Materiale şi tehnici curente sau în curs de dezvoltare pentru restaurarea si conservarea patrimoniului cultural pe suport papetar,* cu următoarele obiective:

○ Definirea priorităților de cercetare în conservarea patrimoniului cultural pe suport papetar;

○ Elaborarea unei proceduri fiabile de evaluare a tratamentelor de conservare;

○ Dezvoltarea protocolului de cercetare.

**Rezultatele Etapei I** s-au concretizat în: *3 studii de documentare* (Analiza şi sistematizarea factorilor care afectează starea de conservare a obiectelor de patrimoniu pe suport papetar; Evaluarea critică a metodelor clasice şi ne-convenționale de conservare; Studiul privind metodele şi tehnicile de analiză ce pot fi aplicate la evaluarea proceselor de degradare a materialelor papetare, precum şi a tratamentelor de conservare aplicate acestora); *Schema generală a procedurii de evaluare* a tratamentelor de restaurare/conservare planificate în proiect şi *Setul de metode şi tehnici de analiză,* alese pentru a fi aplicate de-a lungul derulării proiectului; *Protocolul de cercetare*, care descrie pas cu pas activitățile de cercetare, materialele şi tehnicile ce vor fi utilizate, modul de raportare şi diseminare a rezultatelor pentru fiecare partener; *Activităţi de diseminare* - construcția şi lansarea paginii de internet a proiectului - www.paphercon.ro, comunicări ştiințifice pe tema de cercetarea proiectului la manifestări ştiințifice internaționale - 4 şi la manifestări ştiințifice naționale -3.

**Etapa II** (2013): *Dezvoltarea de materiale şi tehnici noi: Materiale nano-compozite pe bază de derivaţi de chitosan şi tratamente în plasmă rece HF pentru dezvoltarea unor metode noi de conservare a patrimoniului pe suport papetar,* cu următoarele obiective*:*

○ Dezvoltarea unor derivați de chitosan cu funcționalități specifice în conservarea patrimoniului pe suport papetar, precum ar fi capacitatea de hidrofobizare, capacitate de consolidare a structurii papetare şi activitate antimicrobiană;

○ Realizarea unor filme nano-compozite pe bază de derivați de chitosan pentru tratamente de conservare a hârtiei;

○ Studierea efectelor tratamentelor în plasmă asupra diferitor suporturi papetare, inclusiv probe acoperite cu nano-compozite pe bază de derivați de chitosan;

○ Analiza fezabilității unor tehnici de extindere a instalației curente de tratament în plasmă rece HF a suporturilor papetare.

**Etapa III** (2014): *Dezvoltarea unei metode noi de conservare: Combinarea tratamentelor în plasmă rece HF cu aplicarea de acoperiri multi-funcţionale pe bază de derivaţi de chitosan în soluţii sustenabile de conservare a patrimoniului pe suport papetar*, cu următoarele obiective:

○ Construcția instalației de tratament în plasmă rece HF, cu funcționalitate extinsă;

○ Studiul mai multor variante de integrare a tratamentelor în plasmă rece HF cu acoperiri nano-compozite bazate pe derivați de chitosan;

○ Realizarea unei baze de date cu privire la parametrii de bază şi eficiența soluțiilor integrate de conservare, testate în această etapă.

**4. Etapa IV** (2015): *Elaborarea unei metode noi şi sustenabile de conservare: Definirea şi evaluarea noii metode de conservare în condiții reale, pe materiale papetare îmbătrânite natural*, cu următoarele obiective:

○ Elaborarea şi descrierea completă a unei metode noi de conservare sustenabilă a documentelor de patrimoniu pe suport papetar;

○ Validarea noii metode în condiții reale şi specifice conservării patrimoniului pe suport papetar

## Organizații partenere în proiect

Universitatea Tehnică „Gheorghe Asachi" din Iaşi (UTIasi), **coordonator** (CO)

Institutul de Chimie Macromoleculară „P. Poni" Iaşi (ICMPP), partener 1 (P1)

Universitatea "Alexandru Ioan Cuza" din Iaşi, partener 2 (P2)

Complexul Muzeal Național "Moldova" Iaşi, partener 3 (P3)

S.C. IMPEX ROMCATEL S.A. Iaşi, partener 4 (P4)

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Şef lucr. Dr. ing Paul Obrocea (pobrocea@ch.tuiasi.ro)

CONFERENCES REVIEW

## Conferința Internațională ” *Centenary of Education in Chemical Engineering*”,
Iaşi, 26-30 Noiembrie, 2012

# 100 de ani de învățământ de inginerie chimică la Iaşi

În perioada 28-30 noiembrie 2012 s-a desfăşurat la Iaşi Conferința Internațională ***100th Anniversary of Faculty of Chemical Engineering and Environmental Protection*** dedicată momentului în care în urma legii din noiembrie 1912 învățământul tehnic de pe lângă Universitatea din Iasi începe să pregătească specialişti în domeniile: Electrotehnică, Chimie aplicată şi Agronomie. Astfel, anul 1912 marchează o nouă etapă în dezvoltarea învățământului chimic aplicat în cadrul Universității din Iaşi odată cu înființarea *Institutului Electrotehnic* şi a secției de *Chimie aplicată*. Reorganizarea din 1912 a situat chimia, ca secție tehnico-aplicativă în cadrul *Facultății de Ştiinţe* a Universității ieşene.

Principalii animatori ai învățământului chimic aplicat care au contribuit la afirmarea şcolii superioare de chimie au fost iluştrii profesori Anastasie Obregia, Petru Poni, Niculae Costăchescu, Petre Bogdan şi alții.

În condițiile crizei economice din 1929-1933, disputele dintre Politehnici şi Universități au continuat cu intensitate. Noua lege a învățământului superior, din aprilie 1932, legifera acordarea de către Universități a titlului de inginer universitar cu indicarea specialității, titlu care permitea înscrierea în Corpul tehnic.

La 18 martie 1937, Parlamentul a votat o lege, publicată în Monitorul Oficial din 20 martie 1937, care reglementa:

***articolul 1.*** - *pregătirea inginerilor de toate categoriile, cu excepţia inginerilor agronomi, se concentrează în actualele Şcoli Politehnice din Bucureşti şi Timişoara şi în Şcoala Politehnică ce se înfiinţează prin prezenta lege la Iaşi, deocamdată cu catedrele şi conferinţele existente la Facultatea de Ştiinţe, cu organizaţia lor actuală.*

***articolul 2.*** - d*iplomele de ingineri şi Doctori ingineri, cu excepţia Diplomelor de ingineri agronomi, se conferă numai de Şcolile Politehnice denumite mai sus.*

Conform legii menționate, la 6 aprilie 1937, Consiliul profesoral al Secțiilor de Ştiințe aplicate de la *Facultatea de Ştiinţe* din Iaşi, a declarat constituită Politehnica din Iaşi, cu catedrele şi conferințele ale căror cursuri erau urmate de studenții de la Secțiile de Ştiințe aplicate. Acest Consiliu profesoral a decis ca noua Politehnică să poarte numele de Şcoala Politehnică “Gheorghe Asachi”, în memoria primului inginer moldovean, prin ale cărui strădanii au fost impuse ştiințele aplicate în învățământul românesc şi căruia i se datoresc primele promoții de ingineri în țara noastră.

CECE 2012

Cu toate că legea prevedea înfiinţarea imediată a Politehnicii din Iaşi, Ministerul a tergiversat înfiinţarea ***de facto*** a acestei şcoli din motive materiale.

În urma unor proteste energice, marcate şi de o grevă a studenţilor, Ministrul Educaţiei Naţionale a semnat, la 3 decembrie 1937, decizia nr. 205660, de funcţionare a Politehnicii „Gheorghe Asachi" din Iaşi, decizie publicată în Monitorul Oficial nr. 284, din 8 decembrie 1937. La 4 martie 1938 a fost acceptat, de către Minister, regulamentul întocmit de către Consiliul profesoral din Iaşi. La 1 aprilie 1938 s-a aprobat, de către Consiliul de Miniştri, bugetul Politehnicii din Iaşi, iar la 1 octombrie 1938 a început să funcţioneze, cu drepturi depline, Politehnica nou înfiinţată. Astfel, Şcoala Politehnică „Gheorghe Asachi" din Iaşi avea, la înfiinţare trei facultăţi: *Electrotehnică*, *Chimie Industrială* şi *Agronomie*. În primii ani de funcţionare a Facultăţii de Chimie Industrială, disciplinele generale (Chimie, Fizică, Matematică) aparţineau şi secţiei de *Fizico-Chimie* de la *Facultatea de Ştiinţe* a Universităţii „Alexandru Ioan Cuza" din Iaşi. Facultatea de chimie industrială a evoluat ulterior în condiţiile dificile ale celui de-al doilea Razboi Mondial şi refacerii ţării după această catastrofă.

Politehnica ieşeană a fost reorganizată în etape succesive în anii postbelici. Reforma învăţământului, din 1948, a restructurat învăţământul pe baza unor noi principii, cu tendinţe accentuate de corelare cu politica de industrializarii a României.

După Reforma învăţământului, Şcoala Politehnică din Iaşi a fost divizată în: *Institutul Politehnic „Gheorghe Asachi"* şi *Institutul Agronomic „Ion lonescu de la Brad"*.

În noua structură organizatorică, Institutul Politehnic din Iaşi cuprindea patru facultăţi: *Chimie Industrială*, *Electromecanică*, *Mecanică*, *Construcţii*, care au înregistrat, în timp, modificări ale profilurilor de specializare. În cadrul *Facultăţii de Chimie Industrială*, s-au înfiinţat secţii şi catedre specifice, iar durata învăţământului a crescut de la 4 la 5 ani. S-au adăugat apoi cursurile de subingineri zi şi seral desfaşurate în facultate şi în întreprinderi.

După 1990 Institutul Politehnic „Gheorghe Asachi" devine Universitatea Tehnică „Gheorghe Asachi" din Iaşi, iar oferta educaţională, odata cu adoptarea Declaraţiei de la Bologna, se diversifică în concordanţă cu transform[rile economico-sociale din Romania. La direcţiile tradiţionale de studii se adaugă unele noi cum ar fi cele de inginerie biochimică, chimie alimentară, ingineria şi protecţia mediului şi inginerie econmică în industria chimică şi de materiale. În prezent, în *Facultatea de Inginerie chimică şi Protecţia mediului* studiile se desfăşoară în cele trei cicluri: licenţă, master şi doctorat. Intr-o relaţie strânsă cu nevoile educaţionale ale societăţii sunt oferite cursuri post-universitare, de specializare şi perfecţionare. Activitatea de cercetare se bucură de o bogată tradiţie şi se desfăşoară astăzi la un înalt nivel care situează facultatea pe primul loc în universitate. De altfel, programul manifestării menţionate reflectă potenţialul ştiintific valoros al colectivului facultăţii şi interesul participanţilor din ţară şi străinătate implicaţi în strânse relaţii de colaborare.

Programul ştiintific al manifestării a inclus 7 conferinţe plenare şi cca. 140 de comunicări şi postere acoperând domenii de studiu ale chimiei, ingineriei chimice organice şi

anorganice, ingineriei biochimice şi biotehnologiei, ingineriei compuşilor macromoleculari naturali şi sintetici, nanomaterialelor şi nanotehnologiilor, managementului şi ingineriei mediului, cu implicații în toate ramurile de vârf ale activității umane. La această manifestare au participat 120 de invitați din țară şi străinătate fiind reprezentate universități şi institute de cercetare de renume din Anglia, Franța, Germania, Ungaria, Danemarca, Austria, Japonia.

În cadrul aceleaşi manifestări, profesorul Wilhelm Schabel de la Karlsruhe Institute of Technology din Germania a primit din partea Universității Tehnice "Gheorghe Asachi" din Iaşi, titlul onorific de Doctor Honoris Causa, în semn de recunoaştere a contribuțiilor valoroase aduse de domnia sa la dezvoltarea domeniului de inginerie chimică.

Cu acest prilej a fost editată şi o monografie intitulată "***100 de ani de învățământ de inginerie chimică la Iaşi, 1912-2012***", care se constituie într-o lucrare ce evocă filele de istorie parcurse de învățământul tehnic superior de inginerie chimică de la Iaşi de-a lungul unui secol de existență.

Aniversarea acestui centenar al educației în ingineria chimică a fost dedicat tuturor dascălilor care au construit acestă devenire, tuturor dascălilor care duc acest drum mai departe şi tuturor celor care cred în ceea ce poate oferi ingineria chimică generațiilor viitoare.

Prof.univ.dr.ing.Valentin I. Popa - *Membru corespondent al ASTR*

Prof.dr.ing, Teodor Măluțan

## CONFERENCES REVIEW

# Conferința Internațională
# *"Modern Technologies in the Food Industry 2012"*
# 1 – 3 November, 2012 Chişinău

În perioada **1 – 3 noiembrie 2012** s-a desfăşurat, la Chişinău, Conferința Internațională ***"Modern Technologies in the Food Industry 2012",*** organizată de Universitatea Tehnică a Moldovei, în colaborare cu Ministerul Educației, Ministerul Agriculturii şi Industriei Alimentare, şi Centrul Național de Verificare a Calității Prroduselor Alcoolice, din Republica Moldova.

Tematica sesiunii conferinței s-a axat pe aspecte privind ştiința şi tehnologia produselor alimentare structurate în patru secțiuni:

**Secțiunea 1:** ***Procese şi Echipamete Moderne în Industria Alimentară***

**Secțiunea 2:** ***Tehnologia alimentelor***

**Secțiunea 3:** ***Chimia şi Microbiologia Alimentelor***

**Secțiunea 4:** ***Aspecte Economice şi de Management în Industria Alimentară***

Prin structura lucrărilor prezentate şi a participanților, specialişti din industrie, cercetători din institute de cercetare dezvoltare şi universități din țară şi străinătate, firme de consultanță, conferința internațională organizată de Universitatea Tehnică a Moldovei, a asigurat un cadru eficient de transfer către industrie şi mediul academic a rezultatelor cercetării şi ultimelor noutăți din domeniu, de dezvoltare a direcțiilor de cercetare existente şi de identificare a unor direcții noi, de promovare şi consolidare a unor parteneriate durabile.

Sub conducerea unui Comitet Ştiințific Internațional format din personalități cu renume în acest domeniu, pe parcursul celor două zile de comunicări, au fost prezentate 77 lucrări ştiințifice (sub formă de conferințe sau scurte prezentări) şi au fost expuse sub formă de poster 92 lucrări.

În cadrul Secțiunii **Procese şi Echipamete Moderne în Industria Alimentară** au fost prezentate 4 comunicări ştiințifie având ca *temă ambalajele din hârtie şi carton pentru produsele alimentare* sau compozite din fibre celulozice utilizate la filtrarea lichidelor alimentare.

Conferința s-a bucurat de participarea a cca. 250 persoane, specialişti în domeniu, cercetători, cadre didactice universitare, din care 54 au reprezentat instituții din străinătate cum ar fi: Universitatea "Dunărea de Jos" Galați, Universitatea Vasile Alecsandri din Bacău, Universitatea Ştefan Cel Mare din Suceava, Universitatea Transilvania Braşov, Institutul de Chimie Macromoleculară Petru Poni Iaşi, Institutul de Cercetare-Proiectare pentru Celuloză şi Hârtie SC CEPROHART SA Brăila, Universitatea Națională de Tehnologii Alimentare Kiev, Institutul de Comerț şi Economie din Harikov; Academia Națională de Tehnologii

Alimentare din Odessa; Universitatea Națională de Economie şi Comerț „M. Tugan-Baranovschi" din Donețc; Universitatea de Tehnologii Alimentare din Plovdiv, Universitatea „Paisii Hilendarsci", Universitatea „Angel Kanchev" din Ruse, Universitatea de Frigotehnică şi biotehnologii din Sanct Petersburg, etc.

Dintre invitații la această conferință care au susținut comunicări tehnico - ştiințifice s-au remarcat cadrele didactice şi cercetătorii din Universitatea „Dunărea de Jos" Galați Care au prezentat în cadrul conferinței un număr de 14 lucrări.

În afara programului conferinței, participanților le-au fost oferite vizite de lucru şi schimb de experiență la instituții reprezentative din domeniul industriei alimentare din Republica Moldova şi o serie de manifestări turistice şi culturale specifice locului.

Urmare a lucrărilor prezentate, a discuțiilor care s-au purtat între specialiştii din universități, din țară şi străinătate, institute de cercetare şi cei din producție, s-au conturat principalele politici de urmat pentru sectorul industriei alimentare din Republica Moldova, în vederea alinierii acestuia la practicile europene şi aplicării principiilor dezvoltării durabile.

*Comitetul de organizare*

BOOK REVIEW

# HANDBOOK OF WOOD CHEMISTRY AND WOOD COMPOSITES

Second Edition, Edited by Roger M. Rowell, CRC Press, Taylor & Francis Group, LLC, 2013, 687 p, ISBN 978-1-4398-5380-1.

The book presents comprehensive and critical concepts, as well as the future trends in wood chemistry and wood composites, by compiling contributions of international experts in the field. The volume is structured in four main parts, each of them having a variable number of chapters.

Chapter 1 – *Wood and Society (C.D. Risbrudt)* - provides a comprehensive survey on the role of wood in human history, taking into account the environment, sustainability, recycling, energy, sequestering carbon, and the depletion of resources. All the global implications, as economic, social, political and environmental, are referring especially to America.

The first part – **Structure and Chemistry** - contains two chapters:

Chapter 2 – *Structure and Function of Wood (A.C. Wiedenhoeft)* - reviews the basic biological structure of wood and provides a basis for interpreting its properties in an engineering context. The structure of wood is presenting at decreasing scale to understand better its strengths and limitations.

Chapter 3 – *Cell Wall Chemistry (R.M. Rowell, R. Pettersen and M.A. Tshabalala)* - discusses in details the chemical composition of wood and bark in softwood and hardwood, and also presents a complete chemical analysis accounts for all the components.

The second part –**Properties** – contains the following chapters:

Chapter 4 - *Moisture Properties (R.M. Rowell)* - presents valuable information regarding the moisture contents of wood, the distribution of moisture and its effect on different properties of wood, as well as the swelling and shrinking of wood.

Chapter 5 - *Biological Properties of Wood (R.E. Ibach)* - is focused on the biological organism (such as, bacteria, mold, stain, decay fungi, insects, marine borers) and their mechanism of degradation, and describes the most important prevention and protection measures.

Chapter 6 – *Thermal Properties, Combustion, and Fire Retardancy of Wood (R.M. Rowell and M.A. Dietenberger)* - refers to the chemistry of pyrolysis and combustion of wood and its components, as well as fire retardant treatments for wood and the ways to test the efficiency of these.

Chapter 7 – *Weathering of Wood and Wood Composites (P.D. Evans)* - emphasizes some of the more recent research on the weathering and protection of wood and particularly wood composites.

Chapter 8 - *Surface Characterization (M.A. Tshabalala, J. Jakes, M.R. VanLandingham, S. Wang and J. Peltonen)* - presents the most important methods for characterizing surface properties of wood, as microscopic (Confocal Laser Scanning Microscopy, Scanning Electron Microscopy, Atomic Force Microscopy and

Nanoindentation), spectroscopic (Molecular Spectroscopy, Electron Spectroscopy and Mass Spectroscopy) and thermodynamic (Contact Angle Analysis, Inverse Gas Chromatography and Total Surface Energy) methods.

The third section – **Wood Composites** - includes five chapters:

Chapter 9 – *Wood Adhesion and Adhesives (C.R. Frihart)* - discusses some of the fundamental aspects regarding the chemistry of adhesives, together with examples of application, setting and the performance of adhesives.

Chapter 10 – *Wood Composites (M.A. Irle, M.C. Barbu, R. Reh, L. Bergland and R.M. Rowell)* - provides a brief overview of the manufacturing technologies used to make wood-based panel (WBP) products.

Chapter 11 – *Chemistry of Wood Strength (J.E. Winandy and R.M. Rowell)* - describes a theoretical model in order to explain the relationship between the mechanical properties and the chemical components of wood, which has been used further to describe the effects of altered composition on the mechanical properties.

Chapter 12 – *Fiber Webs (R.M. Rowell)* - discusses about the production of a wide variety of low-density, three-dimensional webs, mats, fiber-molded products by using wood fibers, taking into account their testing protocols and applications.

Chapter 13 – *Wood/Nonwood Thermoplastic Composites (C.M. Clemons, R.M. Rowell, D. Plackett and B.K. Segerholm)* - investigates the processing and the properties of wood thermoplastics, nonwood fibers in thermoplastic composites, bioplastics and polylactide fiber composites.

The forth and the last section – **Property Improvements** - includes the chapters:

Chapter 14 – *Heat Treatment (R.M. Rowell, I. Andersone and B. Andersone)* – refers to the heat treatments of wood and the most important industrial processes in obtaining the commercial heat-treated products.

Chapter 15 – *Chemical Modification of Wood (R.M. Rowell)* - presents several approaches to wood chemical modification depending on the specific property and performance and also, the two most important commercial products.

Chapter 16 – *Lumen Modifications (R.E. Ibach and R.M. Rowell)* - is discussing the processing, the properties and the application of wood-polymer composites.

Chapter 17 – *Plasma Treatment of Wood (W. Viöl, G. Avramidis and H. Militz)* - describes a novel technology in the field of wood surface modification and the applications limited to plasmas that can be used for the treatment of suitable wood for industrial implementation.

Chapter 18 – *Sustainability of Wood and Other Biomass (R.M. Rowell)* - evaluates the modern concept of the sustainability and the critical elements involved in a sustainable future.

This book is a valuable source of data and information on the complex subject as wood science. The volume is recommended to all scientists and engineers involved in research and to teachers, graduate and undergraduate students involved in polymer physics, polymer engineering, material science and engineering, fiber science, and chemical engineering.

Diana Ciolacu
*Institute of Macromolecular Chemistry "Petru Poni" Iaşi*

BOOK REVIEW

# FABRICAREA CELULOZEI SULFAT

**Dan Gavrilescu, Grigore Crăciun**

**Editura TEXTE, Dej, 2012, ISBN 978-606-92392-9-2**

Cartea *„Fabricarea celulozei sulfat”,* autori prof.dr.ing. Dan Gavrilescu şi dr.ing. Grigore Crăciun, prezintă stadiul actual al fabricării celulozei prin procedeul sulfat. Deşi în România nu se mai produce celuloză sulfat, existând numai câteva unități de producție aflate în conservare, totuşi se importă celuloză pentru fabricarea unor sortimente de hârtie igienico-sanitară şi pentru cartonul ondulat. Reluarea producției de celuloză este posibilă şi este favorizată de existența materiei prime şi de experiența în domeniu, iar posibilitatea unor investiții în această direcție într-un orizont previzibil de timp nu trebuie exclusă. Din aceaste considerente, apariția unei noi cărți este binevenită pentru că menține interesul pentru ca România să redevină producătoare de celuloză.

Cartea are o întindere de 291 de pagini şi este organizată în opt capitole care urmăresc mersul firesc prin care materia primă este transformată în celuloză. Capitolul 1 este intitulat „Noțiuni generale privind fabricarea celulozei” şi debutează cu clasificarea şi proprietățile pastelor fibroase. Se arată că procedeul sulfat domină autoritar producția de celuloză pe plan mondial şi se prezintă schema generală de fabricare a celulozei. În capitolul 2 „Lemnul ca materie primă pentru fabricarea celulozei” se discută calitatea lemnului pentru celuloză, precum şi operațiile de pregătire a lemnului în vederea dezincrustării. Se atrage atenția asupra importanței calității tocăturii asupra rezultatelor fierberii şi se prezintă câteva soluții pentru valorificarea deşeurilor de lemn.

Problemele fabricării celulozei sulfat sunt prezentate în capitolul 3, cel mai extins al lucrării. Se discută chimismul dezincrustării, insistându-se doar pe principiile reacțiilor

ligninei şi ale polizaharidelor. Se accentuează importanța factorului H ca model cinetic după care se conduce fierberea cu ajutorul calculatorului. Factorii care influențează procesul sunt clasificați în factori principali (adaosul şi concentrația alcaliilor active, sulfiditatea, temperatura şi durata, specia şi calitatea lemnului) şi secundari (hidromodulul, prezența leşiei negre, prezența carbonatului de sodiu). Tehnica fierberii este discutată cu referire îndeosebi la variantele moderne de fierbere discontinuă şi continuă. Se arată că procedeul continuu este preferat datorită avantajelor sale dintre care se evidențiază consumurile specifice de energie reduse.

În capitolul 4 se prezintă operațiile de spălare şi sortare a celulozei, capitolul debutând cu discutarea indicatorilor spălării. Se arată că tehnica spălării a evoluat, folosindu-se în prezent medode de spălare cu fracționarea leşiei negre, iar unul dintre cele mai moderne echipamente este filtrul cu deplasarea fazei lichide. În continuare se prezintă bilanțul de masă la sortare şi indicatorii sortării celulozei. Se arată că sortarea este influențată de mulți factori care țin de natura materialului fibros şi de construcția echipamentului de sortare. Se discută etapele sortării: sortarea brută, sortarea fină şi epurarea pastei de celuloză. În finalul capitolului se analizează schemele de sortare şi se exemplifică cu câteva scheme pentru cele mai cunoscute sortimente de celuloză.

Capitolul 5 este intitulat „Regenerarea alcaliilor” şi la început se prezintă compoziția şi proprietățile leşiei negre. Urmează descrierea etapelor procesului de regenerare: evaporarea, arderea leşiei negre, caustificarea leşiei verzi şi arderea varului. Se arată că, în prezent, leşia neagră se evaporă până la concentrații de 70-75 % s.u. sau mai mult, folosind instalații dotate cu concentratoare de leşie. Urmează procesul de ardere la care se descrie mecanismul şi se prezintă cazanele de regenerare. Aceste echipamente complexe au evoluat în privința performanțelor, mărindu-se considerabil capacitatea de ardere şi presiunea aburului produs chiar până la 10 MPa. Urmează descrierea proceselor de caustificare şi de ardere a varului, unde se insistă pe noutățile care au apărut în ultimii ani. Capitolul 5 se încheie cu o discuție critică despre pierderile de chimicale la fabricarea celulozei.

Înălbirea celulozei este tratată în capitolul 6 al cărții. După o scurtă introducere privind scopul înălbirii şi reactivii folosiți, se prezintă delignificarea cu oxigen, ca etapă obligatorie de reducere a conținutului de lignină din celuloză, înainte de înălbirea propriu-zisă. O atenție deosebită autorii acordă înălbirii cu dioxidul de clor, pe baza constatării că este cel mai folosit reactiv pentru înălbire. Urmează prezentarea înălbirii cu peroxid şi cu ozon, doi reactivi nepoluanți, din ce în ce mai utilizați. Capitolul conține şi informații referitoare la bioînălbire, precum şi cu privire la unii reactivi de dată recentă, cum

sunt polioxometalații. O atenție deosebită se acordă secvențelor de înălbire, sub aspectele stadiului actual şi a tendințelor. Se arată că secvențele de înălbire din fabricile de celuloză intrate în funcțiune în ultimii ani folosesc ca reactiv principal dioxidul de clor, alături de oxigen şi peroxid. Se fabrică frecvent celuloze cu gradul de alb ridicat, 88-89 % sau mai mult. În finalul capitolului se fac considerente legate de recircularea filtratelor între treptele de înălbire şi despre prepararea agenților de înălbire.

În mod firesc, într-o asemenea lucrare, autorii consideră necesar să discute pe larg proprietățile celulozelor sulfat şi acestui subiect i se alocă în întregime capitolul 7 al cărții. Proprietățile celulozelor sunt clasificate în patru grupe: ale fibrelor individuale, proprietățile la nivel molecular, proprietățile de rezistență şi cele optice. Inițial se discută randamentul şi gradul de dezincrustare, caracteristici esențiale care diferențiază sortimentele de celuloză. Fibrele individuale sunt analizate în privința lungimii medii şi distribuției lungimii, grosimii fibrelor şi grosimii peretelui şi deformațiilor. Se continuă cu prezentarea rezistenței mecanice a fibrelor şi cu umflarea. Proprietățile fibrelor la nivel molecular sunt compoziția chimică şi gradul de polimerizare a celulozei. Se arată că în privința compoziției chimice trebuie avuți în vedere, pe lângă componenții principali şi alți componenți cum sunt acizii hexenuronici, precum şi grupele ionizabile din fibrele celulozice, ca şi metalele din celuloză. Viscozitatea celulozei este folosită curent pentru aprecierea degradării celulozei în procesele de fierbere şi înălbire şi, de aceea, această proprietate este discutată pe larg. Se fac considerații şi cu privire la proprietățile de rezistență, precum şi la cele optice. În finalul capitolului se tratează comportarea la măcinarea, o proprietate papetară cu importanță deosebită pentru orice sortiment de celuloză.

Ultimul capitol se ocupă cu impactul de mediu la fabricarea celulozei sulfat. În introducerea capitolului se prezintă principalele ateliere ale unei fabrici de celuloză, sub aspectul consumurilor de materiale şi de energie. Se arată că, din considerente economice, capacitatea minimă a unei linii de fabricat celuloză este de 1000 t/zi şi în prezent se construiesc instalații cu capacitatea de până la 4000 t/zi. Se exemplifică cu cazul a două linii de fabricație cu capacitățile de 1000 t/zi, respectiv 3000 t/zi, pentru care se determină principalele date de proiectare şi consumuri de materiale şi energie. Impactul de mediu este prezentat sub forma emisiilor de ape uzate şi încărcării acestora şi emisiilor în atmosferă.

Cartea „*Fabricarea celulozei sulfat*” tratează într-un mod unitar şi echilibrat subiectul abordat. Unul dintre autori provine din mediul universitar şi susține cursul de fabricare a celulozei la specializarea „Ingineria fabricației hârtiei” de la Facultatea de Inginerie Chimică şi Protecția Mediului

din Iaşi, iar celălalt este un specialist cu experiență îndelungată în producție. Este evidentă strădania autorilor de a prezenta un material formativ, cu caracter practic pronunțat, care să se constituie într-un material de studiu util atât pentru studenții care se pregătesc în această specializare, cât şi pentru specialiştii din producție.

Recomandăm călduros această carte celor care se pregătesc în domeniu sau care activează în sectorul de profil, cu convingerea că ne aflăm în fața unei lucrări utile şi valoroase.

Bucureşti, noiembrie 2012,

Ing. Constantin Chiriac
Director General Executiv
Patronatul Industriei de Celuloza si Hartie – ROMPAP

BOOK REVIEW

# POLYSACCHARIDES IN MEDICINAL AND PHARMACEUTICAL APPLICATIONS

Valentin Popa (Ed.), iSmithers – A Smithers Group Company,
408pp., ISBN 978-1-84735-437-2

In line with the current focus on a sustainable economy, polysaccharides have received a special attention due to the diversity of their resources, non-toxicity, biodegradability, and biocompatibility; they are also renewable sources being capable of chemical modifications. In this order, the book provides a comprehensive overview of researches regarding the use of polysaccharides in the medicinal and pharmaceutical field.

The first chapter, *Configurations, Structures and Morphologies of Cellulose* presents an overview regarding the structure, morphology, sources and physicochemical properties of cellulose. A particular importance is given to micro- and nanostructured cellulose materials, due to their applicability as additives for pharmaceutical formulations, as biocompatible hydrogels or as scaffold materials in tissue engineering.

In Chapter 2, *Hemicelluloses in Pharmacy and Medicine*, a structuring of the sources and the chemical structure of hemicelluloses together with the most interesting applications are presented. The most important properties of hemicelluloses including the controllable biological activity, biodegradability and their ability to form hydrogels are also included in this chapter.

The current applications concerning the fungal exopolysaccharides are summarised in Chapter 3, *Fungal Exopolysaccharides*. Their unique properties of some bioactive fungal exopolysaccharides as immunomodulators, antitumor agents, and effective agents in the treatment of microbial infections and in lowering blood pressure or cholesterol in humans are presented in this chapter. These properties are correlated with their structure, and they depend on the microorganisms which synthesised them and the conditions of production. The heteropolysaccharides, which are complex compounds made up from different sugar monomers, some of which may be negatively charged, are also included here.

Chapter 4, *Pullulan for Biomedical Uses,* is an overview regarding the structure, rheological properties of pullulan solutions and films, their biological properties and some derivatives in solution. The chemical modifications of pullulan such as carboxymethylation and sulfation are also mentioned in this chapter. The possibility of developing different systems based on micro- and nano-hydrogels, films and multilayer formation for drug delivery is also minutely presented in this chapter.

The use of cellulose in the medical field as membranes in dialysis or blood purification is presented in Chapter 5, *Cellulose and Its Use for Blood Purification*.

*Immunomodulatory Effects of Botanical Polysaccharides* (Chapter 6) presents the significant therapeutic potential of polysaccharides extracted from mushrooms, algae and higher plants and the future development of novel compounds with medical value. The antioxidant, mitogenic and antiviral activity, the adjuvant effects, antitumor properties and effects on the leucocyte function are also included in this chapter for these plant-derived polysaccharides.

In Chapter 7, *Pharmaceutical Applications of Cyclodextrins*, the extensive information regarding the physicochemical properties of cyclodextrins and their interest for pharmaceutical applications are summarized. Their ability to form the inclusion compounds with various substances and their high capacity to entrap different active principles are only some aspects of cyclodextrins, included in this chapter, which increase their interest for using the cyclodextrins in the pharmaceutical field.

In *Bioactivity of Chondroitin Sulfate* (Chapter 8) some details about the biological functions of the chondroitin sulfate at the cellular level in treating arthritis are discussed by the authors. This chapter also presents biomaterials containing chondroitin sulfate and its role in improving the biological activity. These materials can be used as scaffolds in cartilage tissue engineering, in wound healing by tissue regeneration or heart valve engineering.

At present, many polysaccharides are used to serve the pharmaceutical needs as carriers for controlled drug release. A lot of examples of micro- and nanocarriers based on polysaccharides applied in various fields as ophthalmic, respiratory, renal, cardiovascular, digestive, immunologic diseases, cancer therapy, neurologic and endocrine pathology are summarized in Chapter 9, *Micro- and Nanoparticles Based on Polysacharides for Drug Release Applications*.

Finally, in Chapter 10, *Carbohydrate-Containing Dendrimers in Biomedical Applications*, the implication of dendrimers based on carbohydrates in drug and gene delivery, synthetic vaccines and the prevention of pathological processes caused by bacteria and viruses are presented.

Covering all aspects, the book is a useful instrument for postgraduate students or scientists from the academic and industrial community working with polysaccharides and their possible applications. This book will be appreciated due to overview regarding the use of polysaccharides and their derivatives in the top fields such as medicine and pharmacy.

Dana Mihaela SUFLET

**TEZE DE DOCTORAT**
**- 2012 -**

**Domeniul Inginerie Chimică – Universitatea Tehnică Gheorghe Asachi Iaşi – Facultatea de Inginerie Chimică şi Protecția Mediului**

# Teza de doctorat: CERCETĂRI PRIVIND SINTEZA UNOR ADITIVI MULTIFUNCȚIONALI PENTRU APLICAȚII LA FABRICAREA HÂRTIEI

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În condițiile actuale în care tehnologiile şi procesele de fabricație sunt supuse cerințelor de inovare, de creştere a competitivității şi productivității, de reducere a impactului asupra mediului şi de utilizare eficientă a resurselor, una dintre marile provocări care se impune în procesele de fabricație a produselor papetare este de a îmbunătăți profilul ecologic al produselor prin dezvoltarea unor noi tipuri de aditivi cu caracter multifuncțional, bazați pe resurse regenerabile şi biodegradabili, în scopul reducerii şi eliminării pe cât posibil a limitărilor impuse de aditivii convenționali de sinteză.

În acest context teza de doctorat "***Cercetări privind sinteza unor aditivi multifuncţionali pentru aplicaţii la fabricarea hârtiei***" are ca **scop** identificarea şi dezvoltarea unor clase de bio-aditivi din resurse regenerabile, pe bază de derivați de chitosan cu proprietăți multifuncționale şi evaluarea efectelor acestora în procesul de fabricare a hârtiei.

**Obiectivul general** al tezei are în vedere Modificarea chimică a chitosanulului în scopul obținerii unor derivați cu proprietăți specifice de hidrofobizare, coagulare/floculare şi antimicrobiene, care prin multifuncționalitatea lor - caracter cationic, proprietăți filmogene, potențial de a forma legături de hidrogen - să permită reducerea numărului de chimicale utilizate simultan şi astfel, simplificarea chimismului proceselor de la fabricarea hârtiei.

**Obiectivele derivate** ale cercetărilor efectuate sunt axate pe:

- Studiul interacțiunilor apă-chitosan, la nivel molecular, în scopul cunoaşterii şi înțelegerii factorilor care le influențează pentru identificarea metodelor de modificare a chitosanului şi de obținere a derivaților de chitosan hidrofobizat;
- Dezvoltarea unor metode de sinteză şi caracterizare a derivaților de chitosan hidrofobizat chitosan N-achilat;
- Dezvoltarea unor metode de sinteză şi caracterizare a derivaților de chitosan cu proprietăți antimicrobiene: cianoetil chitosan şi chitosan cuaternizat;
- Testarea în laborator a derivaților de chitosan sintetizați pentru diferite aplicații la fabricarea hârtiei şi cartonului.

Teza de doctorat este structurată pe 7 capitole, însumează 155 de pagini şi conține 25 tabele, 92 figuri şi 231 de citări bibliografice.