WOODCHEM® 2013

The international congress on wood chemistry

Wood chemistry specialists from all over the world were in Nancy on September 26th and 27th 2013, to take stock of the huge potential that their field of study has to offer.

The 1001 industrial treasures of forest chemistry

Wood chemistry has reached a crossroads. While the inevitable depletion of fossil resources is leading industrialists to search for new raw materials and energy sources, it is in a position to legitimately claim its capacity to take over from oil and its by-products in a large number of fields. Fields in which wood chemistry could meet the needs of companies by relying on a natural, renewable and environmentally friendly resource that is fully in line with the interests of sustainable development. Wood chemistry must hence become more well known and understood by the general public and professionals in order to meet the challenges of the coming decades. Especially in these times of global crisis when research funding is becoming increasingly problematic.

This is the analysis made by over a hundred specialists and researchers present in Nancy on 26 and 27 September for the third edition of Woodchem®, an international symposium which every two years provides an update on the state of play of wood chemistry research and development in the world.

The paradox of an inexhaustible resource that is nevertheless underutilised

French forests today cover a surface area that is larger than it was in the Middle-Ages. Its growth rate is estimated at 70 million cubic meters a year while industry and energy production only consume 50 million cubic meters over the same time period. Nevertheless, although the French forest has constantly evolving renewable potential, problems in terms of the availability and accessibility of wood resources are beginning to rear their head.

This is what Ludovic Guinard[1] from the FCBA Technological Institute explained. For him, “everything that is contained in wood is good”. But it is essential nevertheless to effectively define priorities as to its use.

Within the FCBA, wood is looked at a) from a sales perspective and b) from a social and cultural standpoint. It is important to note that today, wood chemistry is finding it difficult to find a place for itself in the traditional supply chains. As a result, approximately 50% of the wood collected in France is used each year as an energy source (notably wood for heating) and the rest is mainly shared between the paper industries and sawmills. A problem which is not unique to France and can be observed all around Europe, to such an extent that the experts believe that wood demand could exceed supply by 2018. Certain countries are already affected by a relative shortage in this field.

It is therefore vital to reconsider the production networks as quickly as possible, all the more so since the use of wood as a raw material and energy source is scheduled to develop even more by 2030. Forest owners and operators must learn to envisage wood from a chemical perspective way before they plan to use it for heating

purposes. Such a change in mentalities and behaviours that are strongly anchored in traditions will no doubt not occur without clear incentives (regulatory, tax, etc.) from public authorities. But this shift in priorities is absolutely necessary since to a large extent, it conditions the opening up of new markets for wood chemistry.

On a European scale, it would also be good to set up a forestry equivalent of the CAP in order to favour the grouping together and optimisation of wooded plots that are often too small in size. Production and exploitation would become more efficient, while at the same time increasing profitability for owners and operators.

Wood chemistry on an industrial scale: an economic model to build

To make things happen fast, the Canadian Professor Jean-Michel Lavoie[2] advocates for a very pragmatic approach. Wood chemistry has no choice but to quickly develop partnerships with industrialists.

And to interest industrialists, the best approach is to target and highlight what can bring in the most money!

Profitability is an important issue since, contrary to common belief, forest biomass is not free (it is negotiated on average at a price of 60$/ton in the US, not including transport). And its quality has a price too. Hence, for example, wood chips – one of its most easily exploitable forms – is also one of the most expensive since it is particularly sought after by the paper industry.

The profitability issue is also very acute in the field of bio fuels. Although it is possible to produce bio ethanol using wood and without entering into competition with food crops, the cost of doing so is currently far greater than that of producing oil by-products. Just as the gas produced using forest biomass is still much more expensive than natural gas.

Does this mean that the wood-based bio fuels battle has already been lost?

No. For the moment it hasn't been won either but prices at the pump continue to rise and techniques continue to evolve. Sébastien Wiesen[3], from the University of Kaiserslautern, came to present a process that makes it possible to improve the yield of Acetone, Butanol, and Ethanol (*ABE)* production from birchwood. Craig Faulds[4], from the University of Aix-Marseille, for his part, defended the idea of taking advantage of the specific features of certain filamentous fungae to also improve the sugar yield of biomass with the same sugars then being transformed into ethanol. This work has not yet resulted in solutions that are directly exploitable in industry but they show that Research is still making headway.

Adhesives, glues and porous materials: natural applications

For the moment, one of the most obvious applications of wood chemistry is in the glues and resins sector, as explained by Professor Antonio Pizzi[5] from the University of Lorraine.

The tannins extracted from trees can be used to make adhesives that contain no formaldehyde, a product that is considered as toxic and strictly regulated. Various readily available essences are particularly appropriate for producing tannins: Black Mimosa, European spruce, Chilean and Spanish pines and Maritime Pines in France, etc.

The exploitation of these tannins is something that has already been implemented in several countries. Such as in Brazil where Black Mimosa is specially grown and where its tannins are extracted industrially using vacuum evaporators.

The adhesives obtained from tannins can notably be used to make chipboard panels both for construction and carpentry. Moreover, the Swedish company IKEA has expressed its interest in "zero emission" panels designed for home furnishings and manufactured thanks to Mimosa extracted tannins. Increasingly in Japan, these adhesives are being considered for use in the production of construction materials by combining certain waste materials (notably chips and sawdust).

The tannins may also be used to manufacture foams and porous materials with very interesting properties. Some of these "tannic foams" are already on the market in the US and have formed the subject of registered patents. Easy to elaborate, they can be used for heat insulation, shock absorption and many other applications.

In addition, experiments have shown, as Alain Celzard[6] from the University of Lorraine notes, that these foams can practically be designed in a "tailored" manner at the level of their texture and porosity in order to best meet specific needs.

In short, tannins have exceptional qualities. Abundant, cheap and non toxic, they may be used to develop materials that are perfectly capable of competing with the synthetic materials available on the market.

The arrival of a new generation of eco materials

Foams are far from being the only innovative materials that can be made using wood.

Alessandro Gandini[11], from the University of São Carlos in Brazil, reminded those present that the distillation of biomass makes it possible to obtain substances (furfural, furans) that can be transformed into various plastic materials: polyurethanes, thermoplastic elastomers, photo luminescent and photosensitive materials, polyesters, etc. These are all products that could in the long run replace their oil-based equivalents. It is even possible to synthesize a material that is very similar to PET, the most important of the commercial polyesters on the market. Certain new polymers have properties that are comparable to those of Kevlar.

Tannins – once again – are also interesting from this perspective, as demonstrated by Alice Arbenz[12] from the University of Strasbourg. Studies performed on the concentrated tannin from Gambier and Mimosa have shown that it is possible to recover significant quantities of liquid elements called "polyols" that can be used to synthesise various polymers such as polyesters and polyurethanes.

Even the sludge from the paper industry could be upgraded to biodegradable synthetic polyesters as the Valoria project proposes (supported by Véolia) presented by Etienne Paul[13] from the University of Toulouse.

In other words, it is realistic to imagine that tomorrow's plastic materials could one day be produced for the most part using wood. An outlook that would obviously bring about the development of enormous markets over the next few decades.

As healthy as wood

The incense and myrrh brought – according to the Christian tradition – by the Wise Men to baby Jesus prove that the interest in wood chemistry and wood go back a long way. And it is particularly true in the fields linked to health and cosmetics. Let us not forget, for example, that medication as important as aspirin, discovered in the XIX century, was initially extracted from the bark of white willow. Today however, many opportunities seem to be neglected.

This is a situation that Professor Tatjana Stevanovic[7] from the University of Laval in Québec does not understand. He confesses to a true fascination for the surprising diversity of molecules present in forest biomass. Molecules that can be extracted using standard solvents ... and that respect the environment.

The phenols (aromatic chemical compounds) from wood, in particular, have properties that would justify the introduction of bio refineries designed to collect them within existing paper plants. An approach that would be perfectly in line with the economic and ecological principles of “green chemistry”.

Practical applications would then be easy to find.

Studies on yellow birch, the emblem of Quebec, have already made it possible to extract from the tree an anti-inflammatory ingredient with anti-cancerous properties, among thirty other interesting (extractable) compounds. Numerous plants also contain anti-oxidants that are potentially beneficial for Man.

Likewise, Bjarne Holmbom[8], from the University of Abo Akademi in Finland, focused on the chemical defence systems that trees have developed through the course of millions of years of evolution. Systems that rely in particular on substances called “polyphenols” that can be used for human health and some of which have been marketed already for several years: food products that make it possible to fight cholesterol in the blood (Sitosterol, Benecol), a healing ointment with a resin base (Abilar), etc. Many other applications could also be envisaged.

Zineb Kebbi-Benkeder[9], from the INRA in Nancy explained that the knots in trees, that are more dense, also contain large quantities of substances that are beneficial to the metabolism: (“metabolites”), including phenols notably. This concentration is explained by the fact that these substances – that have the specific feature of increasing resistance to putrefaction – have the task of fighting against attacks that trees are subjected to when a branch dies or is ripped off. In any event, they could easily be used to design food and drinks to combat diseases – including certain cancers – in Man.

Peka Saranpaa[10], from the Finnish Forest Research Institute observed that no less than 60 different phenolic compounds were extracted from the needles and bark of Norwegian spruce trees. Forest residues are hence literally full of biochemical products with anti-inflammatory, anti-cancerous, anti-age and chemically protective virtues. Among other things…

Legal constraints and normative opportunities

Subjected to obvious economic and technical constraints, wood chemistry must also obey stringent rules and regulations that can sometimes be obstacles to commercial exploitation of its discoveries. But it would be a great shame if such considerations were to put a stop to initiatives.

A consultant in standardisation from the NEN (Dutch Normative Institute), the Dutch equivalent of the AFNOR), Harmen Willemse[14] considers that these constraints can easily become assets if they are taken into account right from the outset. Sound knowledge and understanding of European standards can indeed guarantee better alignment of the research work to future market needs while facilitating market introduction of new products.

These European standards – as defined by the CEN (European Committee for Standardisation) in agreement with the standardisation bodies of its 33 Member States – make it possible to set in place the essential normative framework. A framework established in full cooperation with the International Standardisation Organisation to achieve optimisation. With the rules hence clearly established, the economic stakeholders have all the latitude they need to effectively redevelop the bio economy of tomorrow, on the basis of healthy unbiased competition. On condition of course, that they are able to identify the most competitive projects.

The last step towards completion

It is essential now for fundamental research in wood chemistry to result in new practical applications. Teams all around the world are working on industrial projects that have a promising future but a lot still remains to be done. As David Pocic[15] from the Fibres Competitiveness Cluster aptly put it, wood chemistry needs a pre-existing and clearly defined "wood market" to be profitable.

Among the initiatives that head in this direction, it is important to note that the Fibres Competitiveness Cluster launched an *Ecolicel®* Innovation Programme in 2009, followed in 2012 by the *Lignocellmarket®* programme from the Xylofutur Competitiveness Cluster (wood from forests and paper).

Programmes with ambitious objectives that range from the development of university research to investment in the appropriate facilities, notwithstanding the development of new competences within the relevant companies.

With an absolute necessity: to find new private partners and new clients!

And things are beginning to move. For example, the Ecolicel® programme has met with over fifty industrialists and operators since the beginning of 2012. And at the current time no less than twenty five projects are already in the research and development phase.

With the reorganisation of forest resource management (the current system dates back to Napoleon), industrial partnership is one of the essential keys able to lead to the opening up of a real market. Current research work will only be fruitful if it is supported financially by companies that are able to understand that this is also where their interests lie.

More than ever, wood chemistry needs daring entrepreneurs.

The next thirty years will be decisive for everything that revolves around oil by-products and it is time, as of today, to at last recognise the tremendous potential offered by wood chemistry.

1. Head of Economic, Energy & Prospective Dpt, Institut Technologique FCBA – "The forest resource and his availability."

2. Ph.D, University of Sherbrooke, Québec – "Producing added value chemicals and biofuels from lignocellulosics: the challenge of the actual technological gaps combined with the market price of biomass."

3. *University of Kaiserslautern, Bioprocess Engineering, Kaiserslautern, Germany* - "Simultaneous Saccharification and Fermentation (SSF) of Organosolv Birchwood Fiber into ABE-solvents in a Fed-Batch Process".

4. INRA UMR 1163 Biotechnologie des Champignons Filamenteux, Aix-Marseille Université, POLYTECH'Marseille (Case 925), 163 avenue de Luminy, 13288 Marseille, France. "EXPLOITING FUNGAL DIVERSITY FOR OPTIMIZED BREAKDOWN AND SACCHARIFICATION OF WOODY BIOMASS."

5. LERMAB, University of Lorraine, Epinal – "From natural resins and composites to wood welding and natural high tech foams - the new age is already here."

6. *University of Lorraine, ENSTIB, Epinal; 2 Institut Jean Lamour – UMR CNRS 7198; Institut Universitaire de France – "*From Solid Foams to PolyHIPEs: a Full Range of Multifunctional, Tannin-Based Porous Solids."

7. Forest and wood department of the University of Laval, Québec, Canada – «Wonderful world of forest extractives - a Canadian case study

8. Åbo Akademi University, Process Chemistry Centre and Oy Separation Research Ab Turku/Åbo, Finland – "Health-promoting extractives from trees – why not."

9. Lermab, USC INRA – Nancy – «SECONDARY METABOLITES IN THE KNOTS OF DIFFERENT TREE SPECIES.»

10. Finnish Forest Research Institute (Metla), P.O. Box 18, 01370 Vantaa, Finland – "VARIATION OF STILBENES IN THE BARK OF NORWAY SPRUCE (*PICEA ABIES* [L.] KARST.)"

11. University of São Paulo at São Carlos, Brazil- "POLYMERS BASED ON FURAN MONOMERS AND FURAN CHEMISTRY: RECENT ADVANCES."

12. BioTeam/ECPM-ICPEES, UMR CNRS 7515, Université de Strasbourg – «New macromolecular architectures based on tannin polyols to develop biobased thermoplastics. »

13. University of Toulouse; INSA, UPS, INP; LISBP, Toulouse ; INRA, UMR792 Ingénierie des Systèmes Biologiques et des Procédés, Toulouse - CNRS, UMR5504, Toulouse – «VALORIA: Preindustrial scale implementation of wastewater treatment sludge valorization route through polyhydroxyalkanoate (PHA) production: description of the project results and applicability to paper effluents. »

14. Netherlands Standardization Institute NEN, Vlinderweg 6, Delft, the Netherlands – "STANDARDIZATION, CERTIFICATION AND LEGISLATION - Drivers of the European bio-based economy."

15. French Fibers Innovative Cluster – "Ecolicel and Lignocellmarket. From biomass to eco-materials… from forest to market."