The future of wood coatings

The future of wood coatings will be strongly influenced by environmental legislation and economic constraints. Research and development priorities are basically driven by rising raw material costs. In view of the ecological aspects, environmental legislation and the increasingly quality and health-oriented consumer, the clear focus will be on water-borne and radcure systems. In addition, renewable resources will start to replace petrochemical products in wood coatings to increase sustainability.

Challenges and opportunities
Claudia Philipp
The reason why we coat wood is obvious. Apart from the aesthetic aspects, the material needs to be protected against mechanical, physical and chemical attack. There are many demands on wood coatings. The requirements for materials for exterior application are different to those for products for furniture or floorings. To satisfy this, several types of binders and additives are available. Furthermore, the application technology used depends on both the binder and the market. The requirements and regulations vary, but they all follow general trends, for example, improvement in sustainability, reduction of harmful substances and reduction of volatile organic compounds (VOC). The relative importance of the various trends depends on the industry in question, on the governmental regulations and on customer demand [1].

There is a noticeable move from solventborne coatings to solvent-free or rather solvent-reduced materials. The technologies used include waterborne coatings, high-solids, radcure coatings and powder coatings. This is driven by environmental and regulatory demands. As price levels of solvent-reduced coatings are much higher than that of the solventborne counterparts, the average price of wood coatings is expected to increase from 2.9 EUR/kg in 2003 to 3.6 EUR/kg in 2013 [2].

The challenges for the wood coating market are to develop and produce regulation-compliant coatings, to deal with the increasing costs of raw materials, to cope with the decreasing production of furniture in Western Europe and to develop a new class of radcure and waterborne coatings with superior performance [2].

In 2006, the major binder used in the European industrial wood-coating market was polyurethane (Figure 1). This is because roughly 50 % of industrial wood coatings are used for furniture and floorings, as solventborne polyurethane coatings are distinguished by their high gloss, flexibility and chemical resistance [2,3]. But waterborne coatings have already increased their market share and were already in second place in 2006 at 18.4 %. Together with the third technology, radcure coatings, they demonstrate the influence of the impending governmental regulations and increasing environmental awareness.

Bio-based raw materials

The increasing costs of raw materials for wood-coating binders are often ascribed to the rising price of petroleum. Thus, a rethinking of the use of petroleum-based raw materials for the chemical industry in general and for the coating industry in particular is predictable. Also the relevance of the need for sustainability leads to the use of renewable resources. This process is slow, but evolving. In general, there are two ways of overcoming the substitution of petroleum-based raw materials: to create new bio-based raw alternatives or to replace the existing chemical structure of petroleum-based raw materials by the chemical/biotechnological modification of renewable resources. The first route contains more risks, but also more potential to create new properties and performance levels. There are, however, many challenges to overcome, such as REACH registration, the need for much research and development, and customers who are not willing to change to, or are afraid of, new binders or technologies. Clearly, the second route has many advantages such as ease of replacement in existing polymer processes, known risk potential and no market risk, because there is no change in product or polymer process. For example adipic acid, a commonly used monomer for polyester polyols, is successfully synthesized from glucose [5,6]. Another example for monomers made of glucose at development stage is acrylic acid which is mainly used in acrylics and UV curing resins [4]. Renewable resources have been used for coatings resins for many years. The focus has been mainly on vegetable oils (e.g. alkyl resins) and cellulose derivatives (e.g. nitro cellulose lacquers). In 2005 around 8 % of all natural oils and animal fats produced in Germany were used in the paints and coatings industry where the predominant material used was linseed oil [7]. However, there is even more potential for the use of natural products for almost all types of common, polymer-synthesis routes. Some of these bio-based monomers have been used in the coating industry for more than 50 years. A good example is linseed oil in alkyl resins. Thus today’s challenge is to find a way to modify other natural products and to use them as a substitute for petrochemicals and furthermore to obtain a larger range of applications and end products with excellent properties. Along with fatty-acid based monomers such as dimer fatty acids [8], long-chain dicarboxylic acids or hydroxylated fatty acids, a new class of monomers is emerging from research and development. For instance, the use of acrylated glucose, made by emulsion polymerization, increases the glass-transition temperature of acrylics and methacrylics and may be a substitute for methacrylate (MMA) [9]. Itaconic acid, produced from the biotechnological conversion of glucose, has the same potential [10]. The presence of a second carboxylic group makes it possible to use it in condensation processes as well. Another diol suitable for polyester polyols or polyurethanes is 1,3-propanediol. The chemical synthesis is based on petrochemicals such as ethylene oxide or acrolein, but biotechnological conversion
starting from glucose or glycerol also exists [11, 12]. The use of 1,3-propanediol is reputed to combine flexibility and hardness in polyurethane dispersions [13]. Another building block for polyesters or polyureas is succinic acid, which today can be produced from glucose on a laboratory scale [14]. These examples, shown in Figure 2, give an idea of the variety of possibilities that exist to use renewable resources in the coatings market [15].

Three technologies
There are generally speaking three types of wood-coating technology: waterborne, solventborne and high-solid materials. Solvent-borne coatings can easily be applied by, for example, spraying, rolling and dipping; whereas water-borne coatings require special expertise. High-solids materials are usually applied by rolling, because they have a higher viscosity.

There are advantages and disadvantages to the different technologies and various resin systems that are used. The disperse phase of waterborne coatings usually contains more than 80 % water and less than 10 % of other solvents such as glycols. Thus, they comply with many VOC regulations and do not have the health issues associated with organic solvents. Acrylic and vinyl emulsions have traditionally been used for a number of wood coatings for indoor and outdoor use, because of their good long-term durability, good block resistance and tend to function better than acrylics. Polyurethane dispersions are considered to be high-quality coatings and their performance is catching up with that of solventborne coatings. Customers are tending to look not only at the coating’s performance; they are also giving priority to low odour, ease of application and water clean-up characteristics. However, there are still hurdles to overcome such as longer curing times and difficulties in obtaining a high gloss level.

Solventborne coatings, with high solvent levels, are often used for indoor application, especially industrial furniture coatings. They have benefits such as fast drying time, excellent gloss and the popular soft and silky feel. Their biggest disadvantage is, of course, the high VOC level and hazardous air pollution (HAP) and the resulting conflict with impending restrictions which require the reduction of these features. Acid-cured coatings show excellent toughness and abrasion resistance, but their main disadvantage is formaldehyde emission. Polyurethanes and unsaturated polyesters usually provide high gloss, flexibility and resistance to chemicals, scratching and abrasion. These advantages justify the higher costs when required for special applications.

High-solid wood coatings have a solid content of 60 80%. The resulting lower solvent level results in a higher viscosity. These coatings are normally used for industrial application. Almost all high-solids materials are UV curable and can be divided into three groups: 100% UV, solvent-reduced UV and water-reduced materials. They are mainly used in the flooring industry. The resin is generally urethane, epoxy, polyester acrylates or unsaturated polyester. The advantages of high-solid, UV-curable coatings are hardness and durability, solvent resistance, quick curing time and little or no VOC. Powder coatings also belong to the high solids family. They have excellent durability, fast drying time and show no delamination, but, today, the high investment costs of this new technology discourage manufacturers from using them.

Various applications
The demand put on wood coatings depends on their field of application. For exterior coatings, the focus is on durability and protection against humidity, sunlight or microbiological attack (Figure 3) [16]. By contrast, interior coatings need to meet VOC regulations, possess high scratch, abrasion and chemical resistance and often require high gloss and a soft-feel effect. Other special applications have further requirements, e.g. parquet flooring, fire-retardant coatings, marine coatings, coatings for garden furniture, chairs, picture frames, doors, fences, musical instruments, kitchens or for use with wood based substrates such as MDF or wood-plastic composites.

The furniture industry represents the largest sector. Here, solventborne coatings are dominant, because of their fast drying time, high properties and low costs. The requirements of coatings for wooden kitchen surfaces and bathroom furniture are different to other furniture coatings. The need to withstand humidity and to be smooth to the touch is important. The standard solution for kitchen and bath cabinets has been, to date, vinyl wrap, but UV-waterborne and 100 % UV are expected to be used in the finishing of kitchen cabinets in the future. UV coatings are also interesting as a replacement for solventborne coatings in the flooring market. However, solvent-free polyurethanes are also popular, because of their good anti-slip and repair characteristics.

Legislation restrictions
The presence of some volatile organic compounds in a coating’s formulation, or during application and the drying processes is undesirable, because of HAP and negative effects on workers. These substances are usually formaldehyde and organic solvents. This is a further reason to move to UV-curing or waterborne coatings.

There are two regulations which control the amount of VOC in wood coatings. Since January 2007, the European PAINTS DIRECTIVE 2004/42/EC has permitted 150 g/l for water-borne coatings and 400 g/l for solventborne. As from January 2010, it will be reduced to 130 g/l for waterborne and 300 g/l for solventborne wood coatings [17]. Furthermore, the European VOC SOLVENTS DIRECTIVE 1999/13/EC regulates the handling of VOC in the coating production and application industry. It applies to companies who work with more than 15 tons of organic solvents per year. Here the emission limit is defined depending on the conditions of use. There are also limits for resin producers who use more than 100 tons organic solvents per year. Other restrictions depend on the year of construction of the equipment and involve specific transition times. The aim is to reduce the use of organic solvents and to create environmental awareness [18].

Another directive is REACH (regulation EC no 1907/2006), which entered into force in June 2007. Because REACH applies to all chemicals imported or produced in the European Union, on one hand, it will make it easy to use registered chemicals, but on the other hand it will be difficult to introduce new raw materials for resin synthesis. This situation is also influencing research and development [19].

References:

Results at a glance
The wood-coatings sector is moving from solvent-borne coatings to solvent-free or rather solvent-reduced materials. In an environment of increasing raw-materials prices and a shrinking market, the challenge is to produce competitive high-performance, products that comply with new legislation. Bio-based raw materials and greatly reduced VOC content are the leading trends. Impending or existing regulations limit the use of VOCs and tighten up product registration.

Corresponding Author: Dr. Claudia Philipp
Fraunhofer-Institute for Wood Research (WKI)
T +49 531 2155 318
claudia.philipp@wki.fraunhofer.de
Figure 1: Total industrial wood coatings market: percentage volume by product chemistry (Western Europe), 2006 (Source: Frost & Sullivan)
Figure 2: Examples for biotechnological building blocks for wood coatings
Figure 3: Natural weathering test according to DIN EN 927-3