UNLOCKING POTENTIAL

Stefano Sassi, Eurotecnica, Italy, explores the potential within urea and melamine applications and developments in this field.

Urea and melamine are two fundamental chemical compounds with diverse applications across various industrial sectors.

While urea is primarily known for its agricultural uses and melamine with resin production, their applications extend well beyond these areas, influencing a wide range of manufacturing processes.

This article will explore the applications of urea and melamine, with a particular emphasis on melamine and the most recent innovations and developments in this field.

Melamine

Melamine, a high value-added chemical compound produced by direct synthesis of urea, is a 2.2 million tpy market, that is expanding and covers a wide spectrum of growing applications.

Across the past 30 years, the global yearly demand for melamine has grown significantly, showing an inexorable upward trend.

A melamine plant is typically integrated with facilities that use natural gas or syngas as feedstock, offering a strategic advantage in calculating and predicting long-term profitability.

The average selling price is 3 - 6 times higher than that of raw urea feedstock, depending on the geographic region. This pricing dynamic significantly enhances the overall profitability of a fertilizer complex while providing a hedge against the typical fluctuations of the fertilizer market.

Melamine applications

Most melamine end-uses see this fundamental building block combined with formaldehyde, to form a strong molecular bond that confers the resulting resins peculiar characteristics, such as hardness and flame-retardancy.

Other applications require the addition of cellulose to form pellets used in the production of thermosetting plastic items.

Melamine is also used as is in the manufacturing of foams, additives and other growing applications.

Wherever possible, melamine is combined with urea in the resins, in order to reduce the cost of the resins themselves since urea has a much lower price than melamine. However, melamine-urea-formaldehyde (MUF) resins showcase lower performance than the resins where urea is not mixed to melamine, such as melamine-formaldehyde (MF) resins. When high performance levels and durability are of the essence, the MF resins are the superior choice.

Figure 1 illustrates the range of end uses and intermediate products involved in the utilisation of melamine and urea, the presence of which is clearly essential for the increase of the level of functionality and comfort in everyday life.

Laminates

Melamine and urea play a crucial role in the production of laminates, enhancing their strength, durability, and aesthetic appeal. Through their application in MF and MUF resins, melamine-based laminates provide a range of benefits, including resistance to heat, scratching, impact, water, and chemicals. These properties make these laminates an ideal choice for high-performance surfaces in various applications, from furniture to flooring.

Key features of laminates containing melamine

- Durability: the resins containing melamine offer exceptional resistance to wear, scratching, and impact, making them ideal for high-traffic areas and surfaces subject to frequent use.

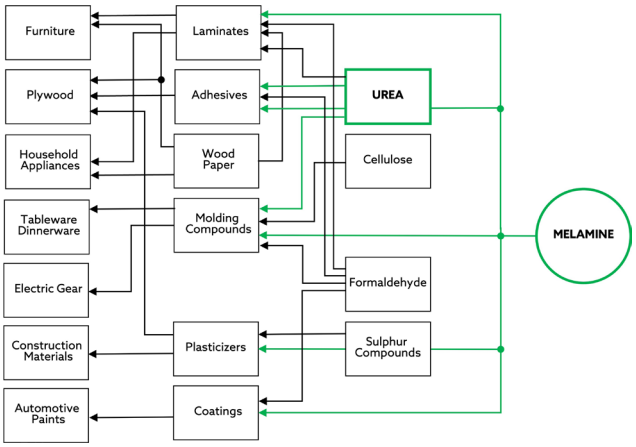

Figure 1. Range of main melamine end uses and intermediate products.

Figure 2. Example of a laminate manufacturing unit.

- High heat and chemical resistance: MF laminates are resistant to high temperatures, detergents, weak acids, and alkalis. This makes them suitable for environments – like kitchens and bathrooms – where surfaces are exposed to heat and chemicals.
- Aesthetic appeal: MF and MUF come in a wide range of attractive finishes and colours. They can mimic the look of wood, stone, or other materials while maintaining the practical advantages of laminate construction.
- Hygenic and easy to maintain: the non-porous surface of MF laminates is resistant to bacteria and stains, making them easy to clean and maintain. This is especially important in kitchens, bathrooms, and other hygienic environments.

Melamine-based laminate applications

MF/MUF are a popular choice in flooring as resins provide durability, scratch-resistance, and are easy to clean, which is useful for both residential and commercial spaces.

Furniture tops are a good example, as melamine laminates provide a hard, durable surface that resists wear and damage from everyday use. Kitchen and bathroom countertops, as melamine-based laminates, are ideal for resistance to heat, moisture, and chemicals typically found in these areas.

Melamine-based laminates' durable and attractive finish that is resistant to impact and moisture makes it a sensible choice for wall cladding.

Melamine-faced boards are commonly used in the production of flat-pack furniture and other cabinets and self-assembly furniture.

Exterior applications provide a perfect example of where melamine laminate aplications are useful, including outdoor furniture or cladding due to their resistance to weathering, heat, and chemicals.

Types of melamine laminates

High pressure laminate (HPL)

HPLs are made by layering multiple sheets of paper impregnated with resins. These layers are then topped with decorative paper that is treated with melamine formaldehyde resin.

The layers are bonded together under high pressure and heat, resulting in a durable, hard laminate sheet. HPL is used where high durability and resistance to impact, heat, moisture, and chemicals are required. It is commonly used for countertops, furniture tops, flooring, wall cladding, and street furniture.

Low pressure laminate (LPL)

LPLs, often referred to as melamine-faced chipboard (MFC), are made by pressing melamine-impregnated paper directly onto a particleboard or fiberboard substrate.

No additional adhesive is needed; the resin in the paper fuses with the board during the pressing process, creating a durable surface.

LPL is commonly used in furniture, particularly in self-assembly furniture and other less demanding applications, such as cabinet panels, shelving, and light-duty furniture. It is also used in flooring, with some manufacturers referring to this as direct press lamination.

Medium density fibreboard (MDF)

MDFs are an engineered wood product made from wood fibres and resin that is compressed and heated to form dense panels. They are commonly used in furniture, cabinetry, and interior applications.

Consistency, soundproofing and workability are features that make the MDF panels versatile and easy to use. They are cost-effective and generally cheaper than solid wood and plywood, making them a budget-friendly option for many projects.

The manufacturing process of the laminates is based on a range of rather sophisticated machines that work on continuous basis. To grant an uninterrupted operability the consistency in melamine quality is as important as purity, to yield a consistent recipe for the MF or MUF resins.

Advantages of melamine laminates

- Versatility: melamine laminates can be produced in a wide variety of colours, patterns, and textures. This allows for flexible design options, from sleek, modern finishes to more traditional looks that mimic wood or stone.
- Environmental benefits: many manufacturers of melamine laminates use sustainable materials, such as recycled paper, wood and eco-friendly resins, making them an environmentally responsible choice for furniture and flooring applications.
- Low hazard profile: melamine forms a very strong bond with formaldehyde. This is a fundamental characteristic when the final product must comply with the most stringent regulations relevant to emission of formaldehyde from the laminate surface.

Moulding compound

Melamine-based moulding compound (MMC) offers several advantages over thermoplastics, particularly in terms of its performance and durability. Some key features include:

- Heat resistance: MMC has superior heat resistance compared to thermoplastics. It can withstand high temperatures without deforming, making it ideal for applications where heat stability is critical.
- Surface hardness: MMC has an extremely hard surface, which is highly resistant to scratching and wear. This makes it suitable for products that are subjected to frequent use or abrasion.
- Dimensional stability: MMC maintains its shape and size over time, even under changing environmental conditions such as temperature and humidity. This dimensional stability is one of the key features that distinguish it from thermoplastics, which can warp or shrink under similar conditions.
- Chemical resistance: MMC shows excellent resistance to a wide range of chemicals, including detergents, weak acids, and alkalis. This makes it ideal for products that may come into contact with such substances, such as kitchenware or automotive components.
- Electrical insulation: MMC is an excellent electrical insulator, making it a preferred material for electrical and electronic applications, especially in withstanding short-circuits.
- Resistance to staining and odour absorption: unlike thermoplastics, MMC resists staining from acidic foods, oils, and extracts, and it does not absorb odours easily, making it suitable for food contact applications.
- Durability: MMC products have exceptional durability, even under harsh conditions, due to their resistance to environmental stress cracking, ultra-violet (UV) degradation, and other forms of wear.
- Colour and aesthetic appeal: the material is available in a wide range of colours, allowing for high aesthetic flexibility in product design. It can also be easily moulded into complex shapes, offering creative freedom in the manufacturing of molded parts.

Applications of MMC

- Tableware and kitchenware: due to its resistance to heat, moisture, and staining, MMC is often used for making durable plates, bowls, cups, and other kitchen items.
- Electrical insulation: its excellent dielectric properties make it suitable for electrical components like switches, sockets, and connectors.
- Automotive parts: MMC is used in components like knobs, handles, and trim due to its resistance to abrasion, heat, and chemicals.
- Industrial applications: it is used for making durable parts in machinery, appliances, and other industrial equipment.

Figure 3. Example of laminate.

Figure 4. Example of laminate.

Figure 5. Melamine based moulding compounds come in a variety of colours.

Adhesives

Melamine-based and melamine-urea-based adhesives are essential in the manufacturing and assembly of laminated panels, boards, furniture, and a wide range of wood-based products. Similarly to laminates and moulding compounds, melamine and urea go in combination with formaldehyde.

Melamine-based adhesives are specifically formulated for bonding melamine laminates to various substrates. These adhesives play a crucial role in ensuring that the bond remains strong and durable across different materials.

Key features of melamine adhesives

Versatility

Melamine adhesives are highly versatile and can bond a wide range of materials. They are effective on both porous materials (e.g., timber, MDF, particleboard) and non-porous surfaces (e.g., melamine surfaces, rigid foam, cultured marble). This makes them ideal for applications in furniture, cabinetry, and construction.

Strength and durability

These adhesives offer strong bonding power, ensuring the structural integrity of products. They provide long-lasting adhesion, even under demanding conditions such as varying temperatures, moisture, and stress.

Resistance

Melamine adhesives often exhibit good resistance to heat, water, and chemicals, which makes them suitable for applications where durability and longevity are essential, such as in kitchen and bathroom furniture, flooring, and cabinetry.

Ease of use

These adhesives are designed to be easy to apply and work well in high-production environments, such as cabinet making and furniture manufacturing. They provide reliable bonding with various fittings like dowels, cams, staples, and screws.

Applications of melamine adhesives

- Cabinet making: in the assembly of laminated boards and wooden panels, melamine adhesives are used to bond the different parts of the cabinet. These adhesives work well with both traditional hardware fittings (like dowels and screws) and modern construction techniques.
- Furniture manufacturing: for the production of furniture such as tables, chairs, and desks, melamine adhesives are used to bond laminated surfaces to the underlying wood or MDF substrates. They are also used in bonding veneers and laminates to furniture pieces.
- Construction: in construction, melamine adhesives are used in the production of panels, decorative surfaces, and engineered wood products. They can also be used for bonding surfaces like melamine-coated particleboard in flooring and panelling.
- Post-forming: melamine adhesives are used in post-forming applications, where a laminate is bonded to a curved or moulded surface. The adhesive ensures that the laminate stays in place, even in complex shapes or forms.
- Automotive and aerospace: in addition to furniture and cabinetry, the automotive and aerospace industries use specialised high-performance adhesives, including melamine-based adhesives, for bonding materials like composites, plastics, and metals.

Plasticisers

Melamine plasticisers or dispersants are specialised chemical additives used to improve the flow, workability, and plasticity of various materials, especially in manufacturing processes involving plastics, concrete, and other construction or industrial materials. The following section describes a more detailed breakdown of how melamine plasticisers function in different applications.

Melamine plasticisers in plastics

In the context of plastics, melamine-based plasticisers are primarily used to increase the flexibility, durability, and processability of plastic materials.

These plasticisers reduce the viscosity of the resin, making it easier to mould and shape the plastic during production. They also help in achieving better material flow during extrusion or injection moulding processes.

Melamine plasticisers in concrete and cement

In concrete and cement, melamine plasticisers (also referred to as dispersants or superplasticisers) are used to improve the fluidity and workability of the mix without adding additional water. This is particularly useful in high-strength concrete formulations where a low water-cement ratio is crucial.

In self-consolidating concrete (SCC), melamine-based plasticisers improve the flow and ease of placement of SCC, which is designed to flow into moulds without the need for vibration.

Melamine plasticisers in other materials

The optimal dosage of melamine plasticisers depends on the specific material and the desired effect.

- Wallboard and gypsum boards: like their use in concrete, melamine plasticisers are employed in the production of gypsum wallboard to improve the workability and consistency of the mixture, allowing for easier manufacturing and handling.
- Clay and ceramics: in the production of clay-based materials, melamine plasticisers may be used to enhance the plasticity of the clay, facilitating moulding and shaping processes without compromising the final product's strength.

Coatings

One of the most significant new applications of melamine is to enhance the flame-retardant properties of various materials, such as polyurethane foams, paints, plastics, and textiles, thanks to the high nitrogen content in the molecule (66% wt.).

When exposed to heat or flames, melamine decomposes and absorbs heat, generating a cooling effect. As it decomposes, melamine releases nitrogen gas, which dilutes the oxygen around the fire, thereby slowing the spread of flames and reducing smoke production. This decomposition significantly delays the time to ignition.

Melamine-based flame-retardants are especially sought after for their environmental benefits, safety, and effectiveness in delaying fire spread. They are halogen-free, making them a more environmentally friendly alternative to conventional halogen-based flame retardants, which can release toxic by-products during a fire, as well as being safer to store and handle compared to traditional halogen-based alternatives. They do not pose the same health risks during manufacturing or application.

Melamine-modified coatings are used in automotive applications, providing durable protection against scratches, corrosion, and UV degradation. The glossy finish also enhances the appearance of vehicle exteriors.

These coatings are also used in the appliances like refrigerators, washing machines, and ovens, resistance to wear, moisture, and heat while maintaining an attractive, glossy finish. This helps appliances retain their appearance over time despite frequent handling.

In addition to flame-retardant and coating applications, melamine-formaldehyde resins are used to enhance the longevity of paper products and textiles, making them resistant to tearing and improving their ability to withstand moisture.

Conclusion

Melamine-based items are incredibly versatile and provide critical benefits across a wide range of industries. From enhancing the durability and aesthetic appeal of automotive parts and appliances, to improving fire safety in textiles, furnishings, and construction materials, melamine derivatives are integral to modern manufacturing.

The increasing demand for high-performance and environmentally friendly flame-retardant solutions is driving the continued growth of melamine-based products in the global market, particularly in automotive, aerospace, and construction applications.

For most of these application, melamine such as Euromel® is a necessary component.

Euromel melamine is only produced by plants licensed and designed by Eurotecnica (Milan, Italy), part of the Proman family of companies, and a leader in licensing and designing advanced methods and processes for the production of melamine and carbon black, and energy storage solutions for the chemical, petrochemical, and energy sectors. With a global reach spanning landmark projects in China, across Europe, the Middle East, Africa and the Americas, Eurotecnica provides sustainable and efficient production processes.

With a history 60 years long, Eurotecnica has licensed and implemented 32 melamine plants of growing sizes, for 1.4 million tpy in licensed capacity and over 8 million t of Euromel melamine cumulatively produced to date. WF