EPOXY RESINS IN FLOORING

ASSESSMENT OF POTENTIAL BPA EMISSIONS

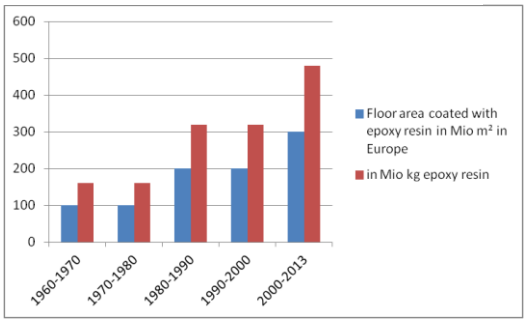
The research on the potential emissions of Bisphenol A (BPA) from manufacturing, using and dismissing epoxy resins in flooring was conducted by Beratungsgesellschaft für integrierte Problemlösungen (BIPRO) on behalf of the Epoxy Resin Committee (ERC). This is part of a series which analyses five key application sectors of epoxy resins in Europe. For more information, contact info@epoxy-europe.eu or visit www.epoxy-europe.eu.

USES & TRENDS

Flooring is the most common application of epoxy resins in the construction and civil engineering sectors. According to ERC estimates, up to 45,000 t of epoxy resins are used in flooring every year.

Floors containing epoxy resin are primarily found in industrial areas and public spaces with all level of people traffic environments: shopping malls, hospitals, institutions, schools, prisons, industrial buildings and sports halls. Their service-life is estimated to exceed 20 years in some cases.

EUROPEAN FLOORING USES IN EUROPE



Flooring made using epoxy resins is highly resistant to impact, abrasion, slippage and chemical spillage. Its versatility is demonstrated by providing adhesion to cement, wood and metal. Surfaces coated with epoxy are seamless and antistatic, easy to clean and maintain. Where hygiene is of the utmost importance, epoxy coatings are the preferred choice because they allow stronger cleaners to be used. They resist external temperatures ranging from 50°C to 100°C (although much higher in some instances) and, during the curing process, the likelihood of material shrinkage is low.

The use of epoxy resins in flooring dates back to the 1950s, although production and usage on an industrial scale began around the 1960s. Its adoption steadily increased over the following decades and, in past years, epoxy-made flooring has been in particularly high demand in Eastern Europe because of improved construction standards and the development of new factories.

MANUFACTURING

The base epoxy resin used in floorings is a substance called Liquid Epoxy Resin (LER). The basic unit of LER is called BADGE or DGEBA, which is a substance produced by reacting epichlorohydrin (55%) with Bisphenol A (45%).

BPA assessment: An ERC industry survey detected low average amounts of unreacted BPA in flooring produced today (<1 ppm). As scientific research demonstrates that BADGE can contain a maximum amount of 10 ppm BPA, the latter figure was used in order to present a highest estimate scenario assessment.

The total European annual consumption of LER in flooring was assumed to be around 45,000 tonnes in the last ten years, with an estimated maximum amount of potentially unreacted BPA of 450 kg annually. Overall this presents the maximum mass of BPA in the whole of Europe that could potentially be released at this stage. It could potentially enter the environment but there are no available scientific studies specifying in which quantities.

Additional BPA may be released when leftovers and excessive quantities of BADGE are washed during manufacturing of the Liguid Epoxy Resins. BPA dissolved in water is assumed to be disposed of via the waste water treatment plants and the sewages. ERC Members indicated that between 5 and 19 g of BPA per produced ton of epoxy resin was released after on-site waste water treatment in the past ten years, with an efficiency BPA removal rate of 80% to

90% of BPA. Assuming a highest estimate scenario (highest BPA quantity and lowest removal rate), it has been estimated that 171 kg of BPA per year would leave the wastewater treatment plant and enter water bodies, possibly dissolving thanks to bacteria or other biological means or degradation through UV-light.

APPLICATION STAGE (COATING)

Depending on the number of reactions between BADGE and the curing agent, the flooring will increase its mechanical strength and resistance. Depending on the type of floor being produced, manufacturers will also add fillers, pigments, liquid and solid extenders, additives such as flow control agents and deaerators.

To apply LER-based epoxy resin on flooring surfaces, the resin is first mixed together with substances called hardeners. Subsequently, LER is applied on the floor with brushes, rollers, trowels, rakes or squeegees. A primer may be applied on the floor before the actual epoxy coating if the existing substrate is particularly weak. An estimated 90% of epoxy resin floors are fully solid mixtures, which means that no water or volatile solvents are added to the coating. The remaining 10% are water or solvent-based.

There are two main types of epoxy resin floors depending on how they are applied. In general, liquid resins are applied following a flow-applied system, while paste-like epoxies (more difficult to apply and less widely used) are applied with trowels. The consistency of both floor types depends on the content of sand added as filler. The more sand in the epoxy resin, the less liquid the epoxy resin gets. Sand also makes the floor more resistant against mechanical stress; hence trowel-applied resin flooring can be increased by sprinkling sand particles on the surfaces' top (before curing). At the end of this process, epoxies are no longer reactive, entailing no risk to human health during service life.

BPA assessment – water: Epoxy resin losses do occur during coating (visit our Worker Safety section for advice on how to best handle them). Epoxy may come in contact with water used to wash surfaces like tools, thus inadvertently rinsing epoxy resin off. No official data of such lost masses are currently available. For this analysis, ERC estimated that 0.1% of the mixed epoxy resin would be lost into water, equivalent to 450 g of BPA emitted per 45.000 t of used epoxy resin. The residues would be treated in municipal wastewater plants with an average minimal removal rate of 61% (data provided by the German Environmental Agency), thus resulting in an annual amount of 176 g of BPA entering water bodies for the whole of Europe (a negligible amount).

BPA assessment – solid waste: The epoxy resin and the hardener are usually mixed together in empty metal buckets to eliminate reactivity and potential hazard generated by both components. Almost 99% of these buckets will be recycled via thermal treatment, leaving 1% of residual buckets destined to general waste, alongside residual resin and BPA traces remaining in the buckets. From a 10 kg bucket, 100 g of metal end up as waste; hence it has been estimated that 4.5 kg of BPA per year in Europe will be burned due to the recycling of the metal of the bucket and therefore exit the life cycle. This mass is not taken further into consideration as it represents a minimal fraction of residues from BPA produced annually.

SERVICE LIFE

The service life span of epoxy flooring depends on its thickness and service conditions. Flooring can be refurbished by overcoating with another layer of resin, hence lasting even longer than 20 years. As the quantity of damaged floors present in Europe remains unknown, ERC only conducted a theoretical calculation of BPA losses.

BPA assessment: Neither the curing nor the mixing of epoxy resins change the BPA content of the flooring. An example calculation for a 700 m^2 floor with a 3 mm coating thickness revealed around 12 g of residual BPA in an epoxy floor. It is safe to say that the total mass of unreacted BPA in cured epoxy floors would remain 450 kg annually as indicated above during manufacturing.

Even when maintenance and cleaning instructions provided by the manufacturers are not followed, only minimal liquid and solid waste containing residual amounts of BPA are released. An instance where epoxy resins – hence, BPA – may leak is an extreme increase in flooring temperature, which is unlikely (some cured epoxy resins are thermally stable up to 200°C). Other potential risk factors include improper installation (which may lead to defects during service life and not only during the application phase), cleaning with or spillage of aggressive chemicals and/or possibly physical aging, provided that maintenance (e.g. overcoating) is not conducted.

END OF LIFE

The analysis of waste highlighted many uncertainties regarding handling and waste classification of used epoxy floors. No reliable data were available and only a qualitative assessment was conducted due to many reasons:

- Most epoxy floors at their end-of-life (at least 50%) are torn out and treated as non-recyclable building-site waste. Depending on the presence of hazardous materials, they are incinerated, landfilled or treated for material recovery of other substances (e.g. mineral rubble and other materials such as concrete).

- Some epoxy floorings last as long as the buildings where they are installed (up to 100 years in the case of concrete buildings). New layers of EP floors are often spread onto older floors at the end of their regular 20-year service life and are finally disposed of and treated separately. No average disposal and recycling rates are available in this case.

- The process for separate disposal of epoxy flooring in the EU remains to be fully defined. Epoxy's classification in the European list of Waste – which is mandated by EU law, the Waste Framework Directive – is still to be defined. Disposal companies in Germany are conducting analysis of epoxy floors which will help in this regard.

- Epoxy resins are hard to recycle, hence it is difficult to go beyond theoretical assumptions. Curing is an irreversible process, enhancing the resins' properties but making it difficult for them to go through a recycling process. An option for thermosetting polymers such as epoxy resins is the so-called particle-recycling, a thoroughly difficult process where the product is grinded and used as filling material.

BPA assessment: Due to the substantial lack of reliable data and information regarding the fate of epoxy floors at the end of their life cylce, it is not possible to offer a reliable assessment of potential BPA release.

CONCLUSIONS

An estimated amount of 171 kg of BPA could be released per year into the environment by using epoxy resins in flooring applications, mostly due to washing procedures at initial manufacturing. The amount of BPA released from epoxy flooring could be quantified during the production and coating stages. During service life no relevant BPA losses are expected (although the quantity of damaged floors present in Europe remains unknown, thus BPA losses could not be fully determined). The end of life (waste) stage presents too many uncertainties to reliably quantify any BPA losses.

Flooring					
Annual epoxy usage mass (2013)	**Annual BPA releases into environment**				
	Production	**Application**	**Service life**	**Waste**	**Total**
45,000 t	max 171 kg	max 176 g	not determined	not determined	> 171 kg

ANNEX: Life cycle stages and related BPA release for EP-floors