UMWELT INTELLIGENT MANAGEN

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Introduction

2005: MPM Environment Intelligence GmbH was established by a management-by-out from FUBA Printed Circuits GmbH

• Owners (since 01/2022)	Felix Kolbe, Metallverwertungsgesellschaft Gottenheim, Martin Töpperwien, Lars Caßebaum und Sascha Erxleben
• CEOs	F. Kolbe, P. Kolbe, M. Leber
• Business Volume	30 Mio. €
• Capacity	25.000 t PCBs, electronic waste and metalliferous dusts
• Recycling rate in 2022	More than 98%

Certificates

- Operating licence: 4. BImSchV Absatz 2 / 8.11.2.4
- Environmental Management System DIN ISO 14001
- Energy Management System DIN ISO 50001
- Health & Safety Management System OHSAS 18001
- Accredited Waste Management Company
- EBA according to ElektroG § 21 Abs. 4
- CENELEC-Standards according to WEELABEX

Necessity of Recycling: **1. Economic Potential !**

- 2019: 53,6 Mt worldwide electronic waste
- Thereof: 9,3 Mt registered and recycelt

- Value: 57,0 Mrd $
- Thereof: 10,0 Mrd $

- Potential: 44,3 Mt valued 47,0 Mrd $

Source: UN Global E-Waste Monitor 2020

Necessity of Recycling: **2. Mineral Planning !**

- Static range for copper: 42 years
- Static range for gold: 16 years

When does it come to the end?

Necessity of Recycling: **3. Efficiancy !**

- Yield rate of copper mines: < 1% per ton of ore
- Yield rate of PCB-Recycling: 20 % per ton of PCB waste

Recycling!

Necessity of Recycling: **4. Envirocare**

UNICEF: Photo of the year 2012

Facilities of MPM Environment Intelligence GmbH

- Line 1: Recycling of unassambled PCBs
- Line 2: Recycling of metalliferous dusts
- Line 3: Recycling of assembled PCBs

Starting Position

Yield rate of PCB-Recycling: 20 % copper per ton of PCB waste

80 % of epoxy resin and fiber

(that still has to be landfilled)

Our Aim and Result

Complete recycling of fiber-reinforced epoxy resin systems with boron halides

- **German patent application DE 102019106524.0**
- **International patent application PCT / EP2020 / 055166,**
- **published on 17.09.2020 under the number WO 2020/182484 A1**

The Market: Carbon Fibers

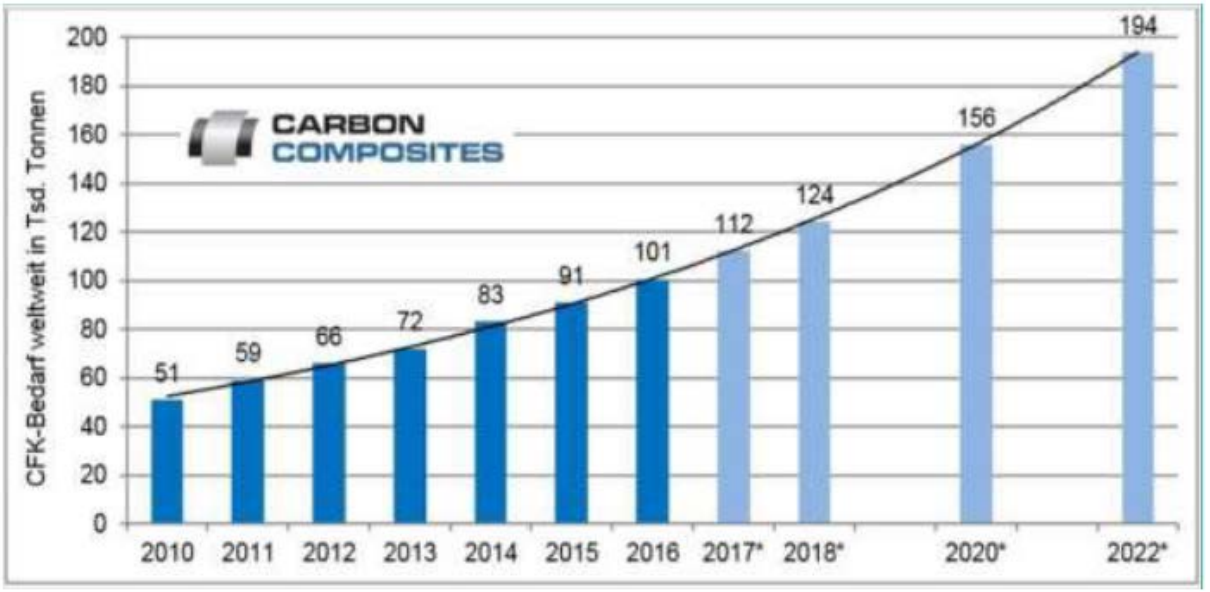


*Figure 1: Development of the global demand for carbon fiber reinforced plastics in thousands of Mg 2010 to 2022 (*estimates; 09/2017)*

The Market: Glass Fibers

Glass fibers are used as the fiber material for around 95% of all composite materials, so that this market significantly exceeds the market of carbon fibers.

We speak about 2.8 million MG glass fibers

(in 2017 alone)

Current Carbon Fiber and Fiberglass Recycling

With regard to the breakdown of CFRP components and the recovery of the fibers, only the pyrolysis process has so far been tested on an industrial scale.

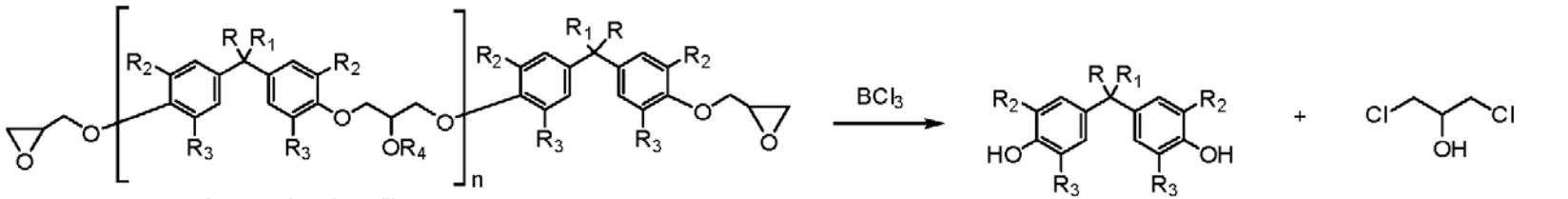
For GRP (glassfiber reinforced plastics) the combined energetic and material recycling in cement works is currently the most sensible recycling method

Result:

- **Only a minimal amount is recycled**
- **The quality of recycled carbon fibers is second choice**
- **The energetic recycling of GRP is not the silver bullet**

Schematic Representation of the New Patent Process

Complete recycling of glass and carbon fiber reinforced epoxy composites with boron halides



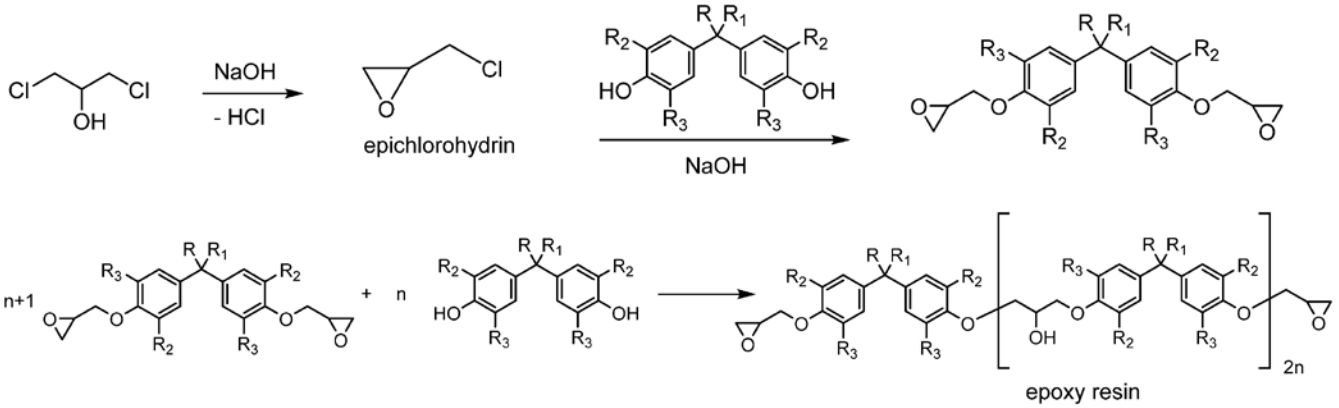
R = R_1 = Me, R_2 = R_3 = H (bisphenol A)
R = R_1 = Me, R_2 = R_3 = Br (tetrabromobisphenol A)
R = H, R_1 = Ph, R_2 = R_3 = H (bisphenol AP)
R = R_1 = CF_3, R_2 = R_3 = H (bisphenol AF)
R = Me, R_1 = Et, R_2 = R_3 = H (bisphenol B)
R = R_1 = Ph, R_2 = R_3 = H (bisphenol BP)
R = R_1 = Me, R_2 = H, R_3 = Me (bisphenol C)
R, R_1 = =CCl_2, R_2 = R_3 = H (bisphenol C2)

R = H, R_1 = Me, R_2 = R_3 = H (bisphenol E)
R = R_1 = R_2 = R_3 = H (bisphenol F)
R = R_1 = Me, R_2 = H, R_3 = *i*-Pr (bisphenol G)
R = R_1 = Me, R_2 = H, R_3 = Ph (bisphenol PH)
R, R_1 = $CH_2CH(CH_3)CH_2C(CH_3)_2CH_2$, R_2 = R_3 = H (bisphenol TMC)
R, R_1 = $(CH_2)_5$, R_2 = R_3 = H (bisphenol Z)
R, R_1 = fluoren-9,9-diyl, R_2 = R_3 = H (bisphenol Z)
R_4 any hardener

Schematic drawing of a novel process for the sustainable recycling of glass and carbon fiber reinforced epoxy composites with boron trichloride

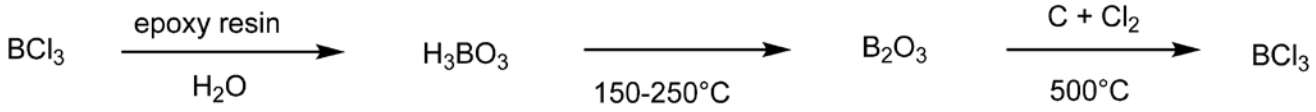
Schematic Representation of the New Patent Process

The recovered fibers are as good as new. Both polymer cleavage products can be isolated, 1,3-dichloropropan-2-ol afterwards transformed into epichlorohydrin again, which is then converted into bisphenol diglycidyl ether, a building block in the manufacture of epoxy resins. It can also be used as a precursor for other resins and polymers.



Reuse of 1,3-dichloro-2-propanol and BPAs for the preparation of epoxy resins

During work-up the used boron trihalides are converted into boric acid. Using a circular BCl_3 process (BCl_3 -> H_3BO_3 -> B_2O_3 -> BCl_3) it proved possible to reobtain pure boron trichloride, which can be used for the recycling of the next batch of glass or carbon fiber reinforced epoxy composites (sustainable process).
In 2007, 3.8 million tons of boron trioxide B_2O_3 were produced worldwide.



Schematic drawing of a circular process for the reuse of boron trichloride

Result

- Carbon Fibers and Glass Fibers can be totally regained in original quality

- The Epoxy Matrix can be cracked and the basic chemicals can be regained to manufacture new epoxy resin or as a precursor for other resins and polymers

- Boron Trichloride can be totally regained in original quality

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