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Materials Science and Technology

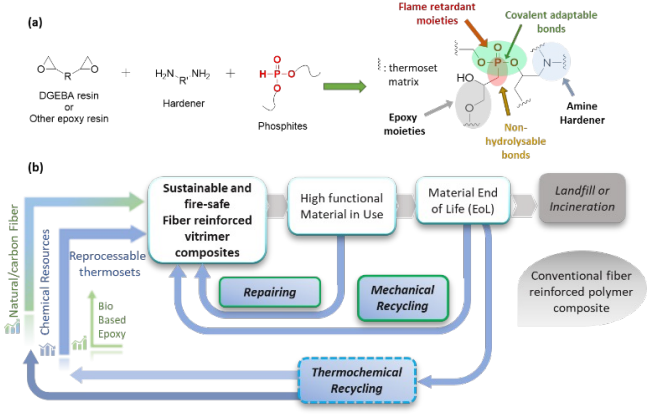
Fiber reinforced polymer composites (FRPCs) are of tremendous economic significance in lightweight material applications. However, their end-of-life waste handling is limited to landfill and incineration due to the non-cleavable cross-linked networks, which creates ecological problems. To this end, we replaced the conventional thermoset matrix with novel vitrimer polymers. The resulting fire-safe fiber reinforced composites, demonstrate extended lifespan as they can repair during use, and be mechanically recycled after end-of-use. Additionally, the presence of phosphorus in the polymer matrix makes them inherently flame-retardant.

Recyclable and flame retardant fiber reinforced thermoset composites

fiber reinforced thermoset composite

Recyclable FR composite material

Contact person
Wenyu Klingler Wu
wenyu.wu@empa.ch
Empa Laboratory for Advanced Fibers
Phone +41 58 765 7912



The core chemistry developed using phosphonated vitrimer approach (a), and the resulting recyclable fire-safe fiber reinforced composite with expanded lifetime (b and c).

Recyclable flame retardant phosphonated epoxy based thermosets enabled via a reactive approach, Chemical Engineering Journal 466 (2023) 143051

Common FRPCs are manufactured from epoxy resins which are not reparable, recyclable or compostable due to their «fixed» networks (C-C/C-N/C-O bonds). Thus the End-of-Life (EoL) management of most composite materials is problematic. In addition, in many applications the FRPCs need to be flame retardant. We tried to tackle these challenges through replacement of common thermoset matrices with novel reversible vitrimer polymers, which contain phosphonated covalent adaptable networks (CANs). These phosphonated networks can be cracked and reformed by external triggers, making them healable and recyclable. Furthermore, the phosphorus-containing polymer matrix is inherently flame-retardant. We have developed simple phosphonated thermosets with inherent flame retardancy and good reprocessability and recyclability, which were used in flax fiber reinforced polymer composite fabrication. The resulting FRPCs showed improved fire-safety, potential healability and promising mechanical re-usability, which can be valuable to recycle non-contaminated composite production wastes.