3D PRINTING-ASSISTED INTERPHASE ENGINEERING IN POLYMER COMPOSITES

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Interphase has a key role when tailoring the performance of composite materials. Nowadays, great efforts are devoted to create composites with smart interphase. Present research trend focuses on the interphase modification rather than to the bulk of polymeric composites. In this respect it is intuitive that 3D printing may have a crucial role in interphase engineering, especially when toughening and (multi)functionality are targeted.

Thermosets, such as epoxy resins (EPs), are often modified with thermoplastics to improve their toughness without seriously affecting their T_g. The preferred morphology of the modifier within the EP matrix is achieved via reaction-induced phase separation (RIPS). The thermoplastic phase may work as healing agent in EP. Healing occurs via chain entanglement of the molecules above the melting of the thermoplastic component. All above information is related to bulk modification. The question arises: How the related knowledge can be transferred to the interphase? How we can produce a morphology-tailored interphase thereby triggering toughening and (multi)functionality (self-healing, shape memory, electric and magnetic conductivity, etc.)?

3D printing is the right tool for that, as outlined below. For example, poly(ε-caprolactone) (PCL) can be fuse-deposited on the surface of reinforcing fabrics in different patterns. Afterward, the reinforcing structure is infiltrated by EP. During infiltration and following curing of the EP the deposited PCL may be partly or fully dissolved. The PCL-rich interphase should work for toughening (interlaminar, -layer) along with self-healing above the T_m of PCL [1]. The patterning wire may contain various nanofillers (magnetite, carbon nanotubes, graphene etc.) to provide the interphase with additional properties such as magnetic or electrical conductivity.

The feasibility of the concept will be shown in the presentation on the example of fabric reinforced thermoset composites, the reinforcing layers of which were patterned by thermoplastic wire in 3D printing. Though this represents a thermoset/thermoplastic combination, it has to be underlined that this 3D printing-assisted interphase engineering can also be used for thermoplastic/thermoplastic and thermoset/thermoset combinations, as well.

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[1] Szebényi G., Czigány T., Magyar B., Karger-Kocsis J.: 3D printing-assisted interphase engineering of polymer composites: Concept and feasibility. eXPRESS Polymer Letters, 11, 525-530 (2017).