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Sustainable Management of Manufacturing Wastes and End-of-Life Parts of Novel fully Recyclable Thermoplastic Composites

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PURPOSE OF THE ABSTRACT

Nowadays, continuous fiber-reinforced composites (CFRC) are widely used in various industrial sectors as aircraft, automotive, marine, E-mobility or renewable energies applications. Their lightweight for equivalent properties in comparison with metallic alloys makes them attractive in reducing their environmental footprint and energy consumption.

The manufacture of CFRC has been based on thermoset composite technologies, but due to new environmental issues and especially a growing need for recyclability, thermoplastic matrix composites could offer some advantages. Thermoplastic-based composites are commonly processed by hot-stamping of pre-impregnated reinforcing plies but thermoplastic matrices usually exhibit high viscosity in the molten state that could impair the fiber impregnation. To overcome this problem, more reliable and cost-effective processing strategies where the in-situ polymerization of a new acrylic liquid thermoplastic resin takes place in the mold have been developed. A further advantage of these processes is that the reactive nature of the resin gives a better fiber to matrix bond, which significantly improves the end-used properties, notably long-term behavior such as fatigue. In this framework, reactive processes like Resin Transfer Molding (RTM), Vacuum assisted resin infusion (VARI), filament winding or pultrusion constitute an appealing approach since it is based on a low-pressure injection of acrylic monomers/oligomers into a mold or a die containing a dry fiber preform. Radical polymerization of the acrylic liquid resin can take place in the mold with the presence of continuous fibers at ambient or moderate temperature, does not require any inert environment and processing cycle time can be adjusted by a careful choice of peroxide initiators, depending on specifications.

The current status is that the mechanical properties of such new system are similar or better than standard continuous fiber reinforced thermoset resins and yet thermoplastic matrix composites could offer important advantages in cycle time reduction, assembly by welding, repair and recyclability. Indeed, acrylic liquid thermoplastic resin lends itself to recycling. The main recycling options currently available for these novel Continuous Fiber Reinforced Thermoplastic Composites (CFRTC) can be broadly divided into mechanical (by thermoforming, compounding or hot compression), physico-chemical (by dissolution, which is a process unique to thermoplastic matrices, allowing recovery of both the polymer matrix and full-length fibers) and chemical (by thermal depolymerization) methodologies.

Composite parts made from this new resin can be easily ground and then compounded with other thermoplastic resins whose properties can be enhanced by the recycled material. The acrylic thermoplastic resin can also be depolymerized into recycled monomer that can then be reused in recycled resin production for the manufacturing of novel CFRTC with exactly the same properties and thus meets the criteria for circular economy.

FIGURES

FIGURE 1

FIGURE 2

KEYWORDS

Thermoplastic composites | in-situ polymerization | Structural applications | Recycling

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