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Even lighter and stronger reinforced composites

Keywords

Advanced composites, Strength, Stiffness, Lightweight composites, Ceramic platelets, Polymer films, 3-D reinforcement, Controlled orientation

Summary

Main feature of the technology is the deliberate control of the orientation of reinforcing elements in polymer-based advanced composites. The technology relies on the use of magnetic nanoparticles to enable the orientation of non-magnetic reinforcing particles (e.g. platelets, fiber, rods) in a fluid, followed by the consolidation of the aligned structure.

Background

Composite materials with reinforcing particles embedded in a matrix material are extensively used in construction, aerospace, automobile and medical industries. These composites employ continuous or discontinuous fibres to reinforce polymeric matrices. Though this reinforcement enhances the mechanical strength and stiffness of the matrix, it is limited to one specific direction. 3-D reinforcement remains challenging due to the limited control of particles in the out-of-plane direction. Recent attempts to solve this issue involve synthetic procedures that show nominal improvements.

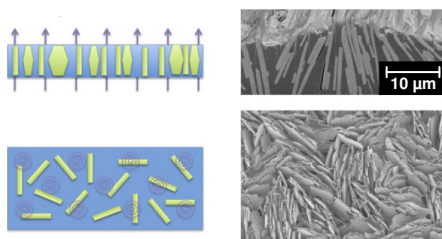


Fig. 1: 3D-oriented reinforcing platelets

Invention

Small quantities of magnetic nanoparticles (below 0.01% by volume) are temporarily attached to the reinforcement particle of interest. The reinforcing particle is then combined with the polymer precursor material that is subsequently cross-linked or solidified. The application of a low magnetic field is required to orient the reinforcing particles (Fig. 1). The surprisingly low magnetic fields required to achieve orientation allow for the use of conventional, cheap magnets to achieve platelet alignment. After the matrix is consolidated, the magnetic nanoparticles can be removed without effect on the reinforced composites. The highly improved material properties can be used for many different applications (Fig. 2)

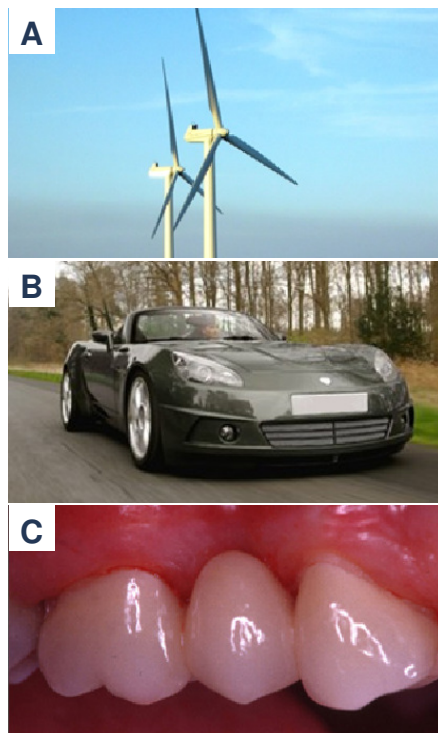


Fig. 2: Possible energy-related (A), transport-related (B) and health-related (C) application of the new reinforced composites

Patent Status

- Patent pending

Features & Benefits

- Deliberate orientation of reinforcement particles in composites
- Increased composite stiffness in any direction
- Out-of-plane tensile strength can be doubled and out-of-plane tensile modulus can be tripled
- Ability to locally reinforce cast polymers in weak points such as holes or corners
- Low magnetic fields required for alignment (0.001—0.01 Tesla) and low magnetic nanoparticle content required with easy removal

Field of Application

- Advanced composites with enhanced delamination strength (Fig. 2A/B)
- Polymer coatings with increased compression stiffness perpendicular to the surface (Fig. 2C)
- Flaw-tolerant advanced composites
- Scratch resistant coatings and laminates

References

- R. M. Erb, R. Libanori, N. Rothfuchs, A. R. Studart, "3-d Reinforced Polymer Films Inspired by Nature". Submitted, 2011.

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