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Combined Zr and Y phosphate coatings reinforced with chemically anchored B_2O_3 for the oxidation inhibition of carbon fiber

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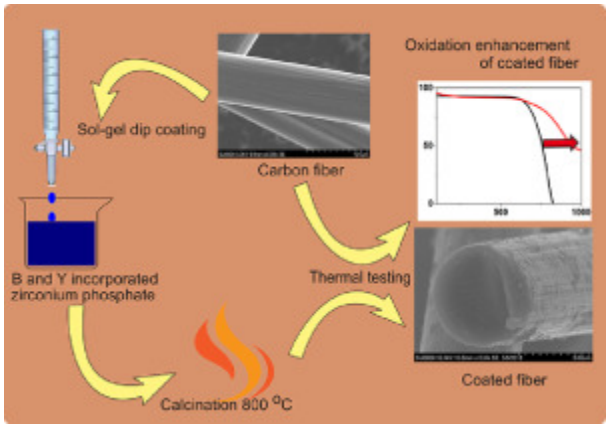
Abstract

The use of carbon fiber-based composites in high-temperature environments has been hindered due to the inferior oxidation resistance of standard carbon fiber. Protective coatings comprised of refractory ceramics have served in enhancing the thermal endurance of carbon fiber significantly. Although zirconium and yttrium-based materials have been highly studied on their refractory characteristics, phosphate-based thermal barrier systems are scarce. Herein, we report the oxidation retardation capability of a B_2O_3-chemically anchored, $Zr_3(PO_4)_4/YPO_4$ coating system on carbon fiber. In-situ, sol-gel-developed coatings with varying thicknesses and constructs were investigated for morphology, crystallography, composition, mechanical properties and thermal integrity. A uniquely consolidated $B_2O_3@Zr_3(PO_4)_4/YPO_4$ molecular arrangement was indicated in coatings by infra-red and X-ray spectroscopy. Ultimately, superior oxidation protection with

an enhancement of ~180 °C over uncoated fiber was exhibited by the integrated nanocoatings, indicating its potential suitability for thermal shielding of carbon-based composites at temperatures in the range of 900–1000 °C. The exhibited improvement in thermal performance was attributed to the fortification provided by the coordinated B_2O_3 network on the fundamental $Zr_3(PO_4)_4/YPO_4$ system.

Graphical abstract



Keywords

Carbon fiber
Oxidation
Zirconium phosphate
Thermal barrier coating