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Why Titanates & Zirconates May be Better Coupling Agents than Silanes for Glass, Aramid & Carbon Fiber and Nano-Reinforcements – and Why Endothermic Titanium Is Better Than Exothermic Cobalt for Peroxide Cured Thermoset Composites

by

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Abstract

Data and references are provided to demonstrate the efficacy of titanates and zirconates in unfilled and filled (inorganic and organic fiber/pigment/nano-particulate) polymers with an emphasis on why titanates & zirconates may be better coupling agents than silanes for glass, aramid & carbon fiber and nano-reinforcements when examined at the interface as explained by the author's four decades of experience in dealing with titanate, zirconate, aluminate, and silane coupling agents in polymeric composites. And why endothermic titanium free radical reduction is better than exothermic cobalt for peroxide cured thermoset composites.

Introduction

Organometallic Ti or Zr coupling agents provide significantly different alternative coupling mechanisms when compared to silanes. The differences are explained through their chemistry and Six Functions. It will be shown that the interfacial coupling mechanism of a neoalkoxy titanate or zirconate via *in situ* surface proton (H+) coordination is superior to silane (OH-) pretreatment condensation mechanisms because of the number of bonds and the differences in hydroxyl group availability from interface to interface. E-Glass is the most widely used reinforcement in MEKP unsaturated polyester composites, but is it the best one? The paper will show why a zirconate can adhere silane sized E-Glass to a fluoro polymer such as ETFE, while the E-Glass alone doesn't. Salt water boil for 240-hour tests will show silanes fail at the interface while zirconates and titanates don't. The paper will also address questions such as: How can a silane couple CNT's or graphene or sulfates or carbonates or cement that have no hydroxyl groups? How can nano-intumescence be achieved with a silane that does not have phosphato heteroatom functionality built into its ligands? The paper will also address the question: Why does the industry continue to use cobalt naphthenate as an accelerator in MEKP cured unsaturated polyester creating exothermic micro-bubbles and the subsequent problems of strength, aging and surface finishing, which can be eliminated by replacing the cobalt with certain titanate coupling agents thus utilizing titanium's latent cure effects, which in turn creates slower endothermic bubble-free cures that can use heat (40°C) or more aggressive peroxides to speed cures even faster than cobalt resulting in fourteen-fold increase in the impact strength of an unfilled and unreinforced unsaturated polyester? Current work from the literature will be shown and some of the more interesting developments in the field of alternate interface technologies will be reviewed. New generation 1.5-nanometer hybrid organometallics are also discussed.

Note: The full copy of the technical paper is available upon execution of a NDA.