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REVIEW

Electrorheological response of polyaniline and its hybrids

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One of the remarkable applications of conducting polymers is as an electrorheological (ER) fluid which is a smart suspension of polarisable particles dispersed in an insulating liquid with the capacity to effect a phase transition from a liquid-like to a solid-like state. Polyaniline (PANI) and its hybrids with inorganics or other polymers are active candidates for ER materials due to their various advantages, e.g., easy synthesis, controllable conductivity, and less friction than pure inorganics. In this short review, we review recent progress in the synthesis of semi-conducting PANI and its hybrids with diverse morphologies and their ER performance measured by a rotational rheometer using the applied electric field strength. The dielectric properties of these ER fluids, as an important analytical method for their ER performance, are also discussed.

Keywords: electrorheological fluid, polyaniline, composite, yield stress, dielectric constant

Introduction

Electrorheological (ER) fluids are a category of smart materials, wherein their rheological properties can be controlled by an external electric field (Halsey, 1992; Hao, 2001). The solid particles dispersed in the ER suspensions are polarised by an applied electric field strength and then connected with the adjacent particles to form chain-like structures with a strong dipole–dipole interaction along the applied field direction. Hence, they exhibit a phase transition from liquid-like to solid-like. During this rapid and electrically controllable process, the rheological properties of the ER fluids change significantly, from a Newtonian-like fluid with good fluidity and shear-independent viscosity to a Bingham plastic possessing non-vanishing yield stress, enhanced shear viscosity, and dynamic moduli. Various industrial applications are thus achievable by using ER fluids on the basis of their controllable and reversible phase-transitions (Coulter et al., 1993; Han & Choi, 2008). In addition, the ER technology has been recently applied to the efficient energy production of crude oil and refinery fuels (Tao, 2011).

Since its first discovery by Winslow (1949), research into exploring the mechanism of ER fluids and developing novel ER materials has attracted more and more interest. Several ER mechanisms and models of their dynamics and phenomena are available. The first ER materials to be discovered were wet-base systems, in which a trace of absorbed water or surfactant was considered necessary for their ER effect by the mechanism of an adhesive water bridge or an electric double-layer between the particles (Kim & Klingenberg, 1996; Klass & Martinek, 1967). However, in the case of the anhydrous ER materials discovered later, their ER effect was known to be generated by the dielectric mismatch between the particles and the carrier medium under the applied electric field strength. Accordingly, a polarisation model was proposed to explain this kind of ER fluids and attracted the most attention out of all the microscopic models (Davis, 1992; Parthasarathy & Klingenberg, 1996). Although many researchers and their experimental systems have supported the polarisation model, some other ER observations could not be interpreted using this model, such as the rheological property dependence on the electric field frequency and the particle conductivity. In general, conductivity mismatch between particles and liquid medium, rather than dielectric constant mismatch, was regarded as a

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