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Reply to Comment on “Preparation and Enhanced Electrorheological Activity of TiO_2 Doped with Chromium Ion”

ARTICLE *in* CHEMISTRY OF MATERIALS · MAY 2006

Impact Factor: 8.35 · DOI: 10.1021/cm0607381

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Hong et al. commented on our research results[1] by analyzing the data of the flow curve for a 10 mol % Cr-doped TiO_2 electrorheological (ER) fluid via three different constitutive equations, including the Bingham model, the De Kee−Turcotte model, and their proposed shear stress model. They noted that their shear stress model provided a good fit to our data compared to the Bingham model.[2] Indeed, the Bingham fluid model is the simplest model to describe the complex flow of ER fluids under electric fields, and this model involves two regimes, the pre-yield behavior for shear stress less than the yield stress and flow or post-yield behavior for shear stress beyond the yield stress. In fact, many experiments have found that the flow curve of ER fluids should consist of three regions, pre-yield, yield, and flow regions.[3] Specifically, the yield process is not sharp, and complex shear stress behaviors in this yield region are often found.[4] From the flow curves as a log−log plot in a wide shear rate range,[5] some significant deviations from the Bingham fluids model can be noted. Figure 1 shows the flow curve of the shear stress−shear rate measured by the controlled shear rate mode in the 0.001−1000 s^{-1} range for a 10 mol % Cr-doped TiO_2 ER fluid under 2 kV/mm and 3 kV/mm electric fields. Three different shear stress regions, which are marked as regions I, II, and III, are shown in the figure. In region I, the shear stress increases with the shear rate and reaches a maximum. In region II, the shear stress decreases as a function of shear rate below the critical shear rate of about 20 s^{-1} for 3 kV/mm and 10 s^{-1} for 2 kV/mm. This critical shear rate increases with electric field strength (as shown by the solid line in the figure). The behavior of stress decrease in region II is deviation from the Bingham fluids model. Finally, the shear stress increases again with shear rate in region III. It is well-known that in region I the shear rate is very low, the fibrous structure of ER fluids is not broken, and the shear stress is dominated by the electrostatic interaction among particles. When the shear rate is very high (in region III), the fibrous structure is broken fully and the hydrodynamic force becomes dominant over the rheological behavior. However, in region II the competition between electrostatic and hydrodynamic force results in complex shear stress behaviors.[6] Therefore, the shear stress behaviors in region II are interesting for an understanding of the ER response and microstructure change of ER fluids under electric and shearing fields. But the Bingham model does not treat this region well. Therefore, we feel that the improved model by Choi et al., which can accurately treat the shear stress in this low shear rate region, may be interesting for deducing further information to better understand the change of microstructure and ER properties of ER fluids under electric and shear fields.

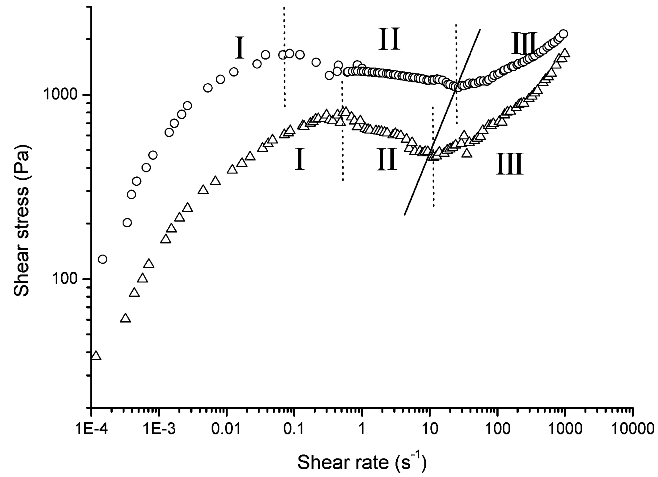

Figure 1. Flow curves of shear stress−shear rate of the typical 10 mol % Cr-doped TiO_2 ER suspension under 2 kV/mm (triangle) and 3 kV/mm (circle) electric field (volume fraction = 18 vol %, T = 25 °C, measured by a CR mode with Therm-HAAKE RS600 electrorheometer).

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Received March 29, 2006
Revised Manuscript Received April 14, 2006

CM0607381

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(1) Yin, J. B.; Zhao, X. P. *Chem. Mater.* **2004**, *16*, 321.
(2) Hong, C. H.; Choi, H. J.; Jhon, M. S. *Chem. Mater.* **2005**, *11*, 2771.
(3) Gamota, D. R.; Filisko, F. E. *J. Rheol.* **1991**, *35*, 399
(4) Block, H.; Rattay, P. In *Progress in Electrorheology*; Havelka, K. O., Filisko, F. E., Eds.; Plenum Press: New York, 1995; p 19.
(5) Choi, H. J.; Cho, M. S.; To, K. *Physica A* **1998**, *254*, 272.
(6) Parthasarathy, M.; Klingenberg, D. J. *Mater. Sci. Eng., R* **1996**, *17*, 57.

10.1021/cm0607381 CCC: $33.50
Published on Web 05/04/2006