Supporting Information

Fast and facile fabrication of graphene oxide/ titania nanocomposite and its electro-responsive characteristics

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Experimental Section:

Initially, GO was prepared by modified Hummers method.[1] We modified the surface charge of hydrophilic TiO_2 nanoparticles (R900, Dupont, USA) by dispersing them in 1M HCl solution. After that, the electrical property of TiO_2 was changed from a negative to positive charge (due to the adsorption of H^+) which was confirmed by a zeta-potentiometer (15.47 mV). The prepared GO was dispersed in di-water by sonication, and then the surface modified TiO_2 nanoparticles were added. The weight ratio of GO and TiO_2 added was 2:1. After 6 h stirring of the mixture solution to obtain a homogeneous suspension, the resulting nanocomposite was collected by a centrifuge and dried in oven at 60 ºC. As the surface of GO presents a negative charge (tested by zeta potentiometer, -31.37 mV), the positive-charge TiO_2 nanoparicles can be decorated on the GO surface by the negative-positive electrostatic attractive force.

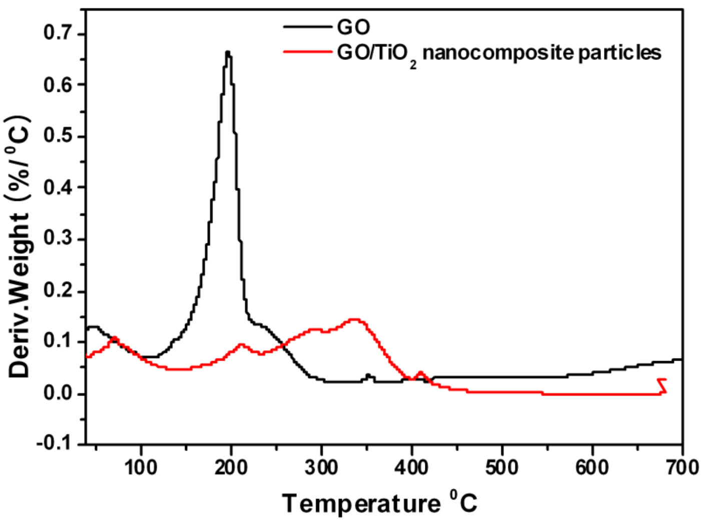

Fig.S1. DTG traces (40-700 °C) of GO and GO/TiO_2 nanocomposite.

The differential thermogravimetric analysis (DTG) patterns in the range from 40-700 ºC of both GO and GO/TiO_2 nanocomposite are used to describe the thermal decomposition temperature as shown in Fig.S1. The GO presents sharp DTG peak at 198 ºC, corresponding to the decomposition of the oxygen functional groups on its layer. In the case of the GO/TiO_2 nanocomposite, there are 3 weak peaks at 212, 280 and 338 ºC, all assigned to the combustion of carbon skeleton.

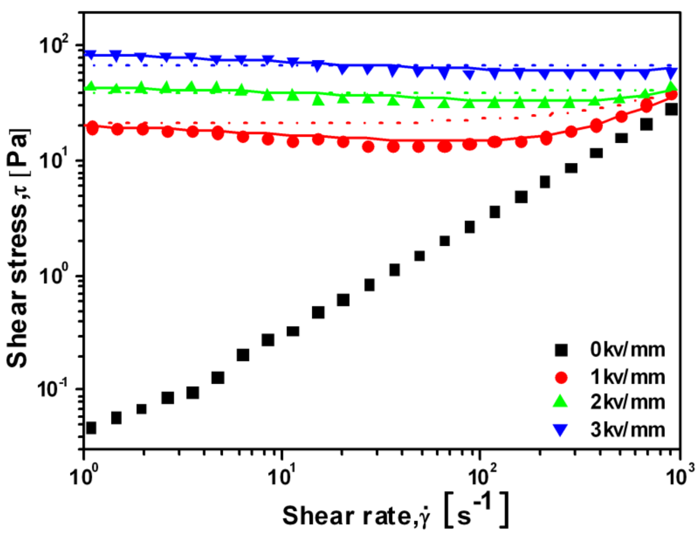

Fig.S2. Shear stress vs. shear rate of GO/TiO_2 nanocomposite (15 wt% particle concentration) based ER fluid. Solid, and dotted lines are from the CCJ model and Bingham model, respectively.

We prepared the GO/TiO_2 nanocomposite particles based ER fluid (15 wt% particle concentration) by dispersing in 30cS silicone oil and its ER characteristics were investigated using a Couette-type rotational rheometer equipped with a high voltage generator in a controlled shear rate (CSR) mode. The shear stress vs. shear rate curve for various applied electric field was shown in Fig. S2. Without an electric field, the ER fluid presents nearly a Newtonian fluid, in which the shear stress increases linearly with a shear rate. However, when exposed to an external electric field, the dispersed nanocomposite got polarized and formed chain-like structure as like observed in OM images shown in Fig. 6. With increasing electric fields, the shear stress increased for all shear rates as like a Bingham fluid. [2] This behavior can be described by the following equation:

$$\tau = \tau_0 + \eta_0 \dot{\gamma}, \qquad \tau \geq \tau_0$$
$$\dot{\gamma} = 0 \qquad \tau < \tau_0$$

Here, τ is the shear stress, τ_0 is the yield stress and is related to an electric field strength, $\dot{\gamma}$ is the shear rate, and η_0 is the shear viscosity.

To fit the experimental data well for various ER fluid, the Cho-Choi-Jhon (CCJ) model [3] is proposed as following:

$$\tau = \frac{\tau_0}{1 + (t_1 \dot{\gamma})^{\alpha}} + \eta_\infty \left[1 + \frac{1}{(t_2 \dot{\gamma})^{\beta}}\right] \dot{\gamma}$$

Here, τ_0 is the dynamic yield stress defined as the extrapolated stress at low shear rate region, η_∞ is the viscosity at a high shear rate and is interpreted as the viscosity in the absence of an electric field. The exponent α is related to the decrease in the shear stress, the exponent β has the range $0 < \beta \leq 1$, since $d\tau/d\dot{\gamma} \geq 0$. The parameters t_1 and t_2 are time constants.

The flow curves of GO/TiO_2 nanocomposite (15 wt% particle concentration) based ER fluid have been fitted with these two models, the optimal fitting parameters are summarized in

Table S1. Compared with Bingham model, the six parameter named CCJ model can fit the flow curves more accurately especially at higher electric fields.

Table S1 The optimal parameters appeared in each model equation obtained from the flow curves of GO/TiO_2 nanocomposite (15 wt% particle concentration) based ER fluid.

Model	Parameters	Electric field strength (kV/mm)		
		1	2	3
Bingham	τ_0	21	40	68
	η_0	0.02	0.001	0.002
CCJ	τ_0	22	47	160
	t_1	0.01	0.0015	0.38
	α	0.48	0.38	0.13
	η_∞	0.03	0.02	0.015
	t_2	0.20	0.08	0.69
	β	0.40	0.80	0.69

1. W. S. Hummers and R. E. Offeman, *J. Am. Chem. Soc.*, 1958, **80**,1339–1339.

2. H. J.Choi and M.S.Jhon, *Soft Matter*,2009,**5**,1562-1567.

3. B. Wang, M. Zhou, Z. Rozynek and J.O. Fossum. *J Mater. Chem.*, 2009, 19, 1816–1828.