The chemical stability and cytotoxicity of carbonyl iron particles grafted with poly(glycidyl methacrylate) and the magnetorheological activity of their suspensions

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Supporting information

The reaction of iron in aqueous solution of hydrochloric acid proceeds [1] according to the following equation:

$$\mathrm{Fe} + 2\mathrm{HCl} + 6\mathrm{H_2O} \rightarrow [\mathrm{Fe(H_2O)_6}]\mathrm{Cl_2} + \mathrm{H_2} \qquad (1)$$

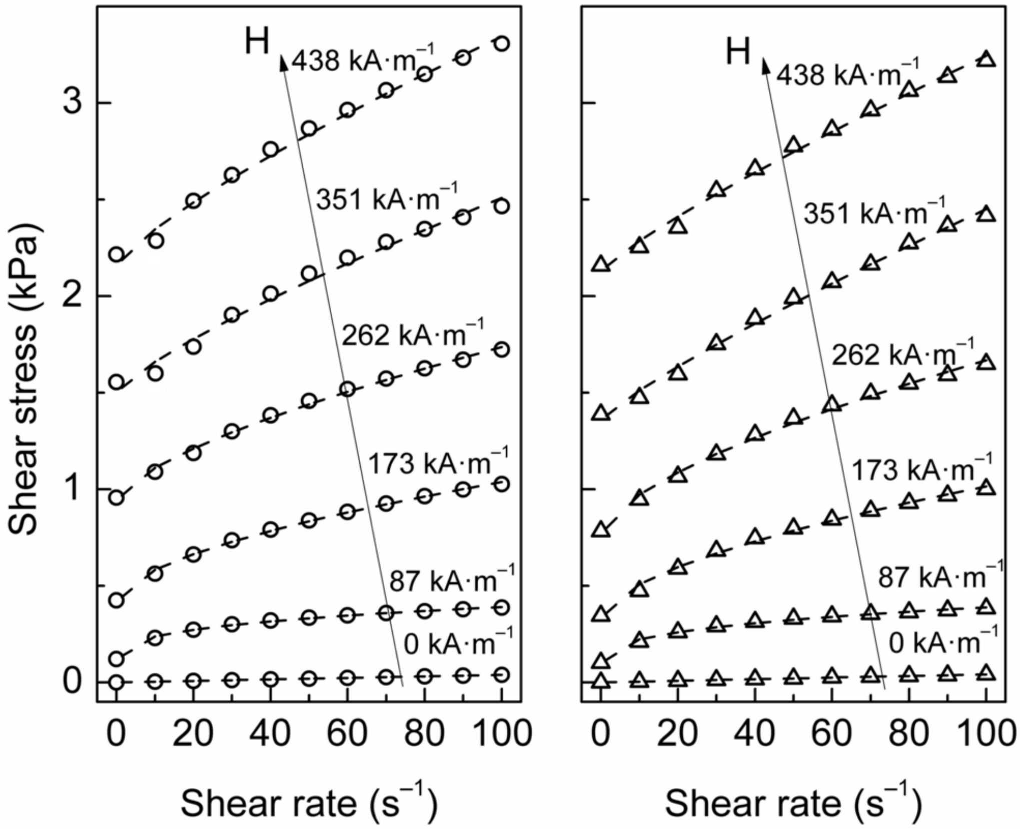

Figure S1. Rheograms of the MR suspensions containing 40 wt.% of CI-PGMA-1 particles (*open circles*), and CI-PGMA-2 particles (*open triangles*) showing experimental data fitted with the HB model (*dashed lines*) under various magnetic field strengths.

Non-linear regression was performed on Origin® (© OriginLab Corporation) curve fitting package in order to determine τ_0, *K*, *n* parameters of Herschel-Bulkley (HB) model. The accuracy of HB predictions was assessed with three statistical indicators. Validity of correlation coefficient (R_C^2), to evaluate the fit of non-linear models has been questioned [2–4], therefore the sum of square errors (SSE), and the root mean square error (RMSE) are also reported. These parameters are defined according to equations:

$$SSE = \sum_{i}^{N} \left(\tau_i - \tau_p\right)^2 \quad (2)$$

where τ_i and τ_p are observed and predicted shear stresses, and

$$RMSE = \sqrt{\frac{SSE}{N - p}} \quad (3)$$

where N is the number of measurements, and p denotes the number of parameters of the model. For further references see Kelessidis *et al*. [4].

Table S1. Statistical evaluation of the HB model predictions

Magnetic field	**0 kA·m^{-1}**	**87 kA·m^{-1}**	**173 kA·m^{-1}**	**262 kA·m^{-1}**	**351 kA·m^{-1}**	**438 kA·m^{-1}**
MR suspension of bare CI particles						
$\boldsymbol{\tau_0}$ **[kPa]**	1.26e–05	0.120	0.519	1.215	2.046	2.941
K **[kPa·s^{n}]**	4.59e–04	0.115	0.143	0.091	0.039	0.035
n **[-]**	0.929	0.258	0.395	0.557	0.761	0.782
$\boldsymbol{R_C^2}$	0.999	0.991	0.990	0.998	0.997	0.997
SSE [kPa^2]	5.04e–07	0.003	0.013	0.004	0.011	0.012
RMSE [kPa]	2.51e–04	0.020	0.041	0.013	0.037	0.039
MR suspension of CI-PGMA-1 particles						
$\boldsymbol{\tau_0}$ **[kPa]**	1.26e–05	0.107	0.417	0.944	1.503	2.160
K **[kPa·s^{n}]**	4.36e–04	0.061	0.044	0.035	0.024	0.029
n **[-]**	0.973	0.333	0.571	0.675	0.804	0.802
$\boldsymbol{R_C^2}$	0.999	0.999	0.999	0.998	0.991	0.991
SSE [kPa^2]	3.35e–08	1.45e–04	0.0007	0.002	0.020	0.025
RMSE [kPa]	6.48e–05	0.004	0.009	0.016	0.049	0.056
MR suspension of CI-PGMA-2 particles						
$\boldsymbol{\tau_0}$ **[kPa]**	1.26e–05	0.089	0.332	0.768	1.359	2.130
K **[kPa·s^{n}]**	4.63e–04	0.060	0.045	0.046	0.021	0.021
n **[-]**	0.971	0.347	0.587	0.642	0.854	0.853
$\boldsymbol{R_C^2}$	0.999	0.998	0.998	0.998	0.997	0.997
SSE [kPa^2]	5.81e–08	3.36e–04	0.002	0.003	0.007	0.008
RMSE [kPa]	8.52e–05	0.007	0.017	0.020	0.029	0.032

Computed parameters confirmed almost Newtonian behavior of all magnetorheological (MR) suspensions in the off-state, thus behavior with almost zero yield stress and non-Newtonian index close to 1. However, after the application of an external magnetic field, yield stress appeared and pseudoplasticity occurred, as supported by corresponding parameters. High values of R_C^2 for all data samples, and generally low values of SSE and RMSE in majority of the cases (Table S1) indicate that the experimental data are in a very good agreement with HB model predictions. To conclude, considering these results, the HB model appeared to be a reliable analysis tool for flow curve fitting of prepared MR suspensions.

References

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