Supporting Information for

# Ecoresorbable smart fluids with controlled electroresponsive properties by various metal doping

Hyukjoon Gwon, Sohee Park and Seungae Lee*

*Department of Chemical Engineering, Konkuk University, 120 Neungdong-ro, Gwangjin-gu, Seoul 05029, Republic of Korea. Tel.: 82-2-2049-6109; E-mail: salee@konkuk.ac.kr

**1. High-magnification TEM image of the Mg-doped HNP.**

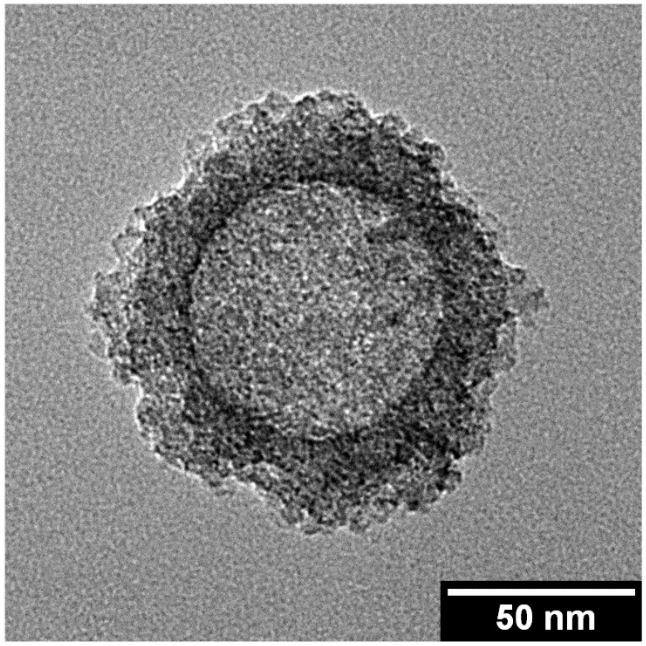


**Fig. S1** High-magnification TEM image of the Mg-doped HNPs.

**2. SEM micrographs of various metal-doped HNPs.**

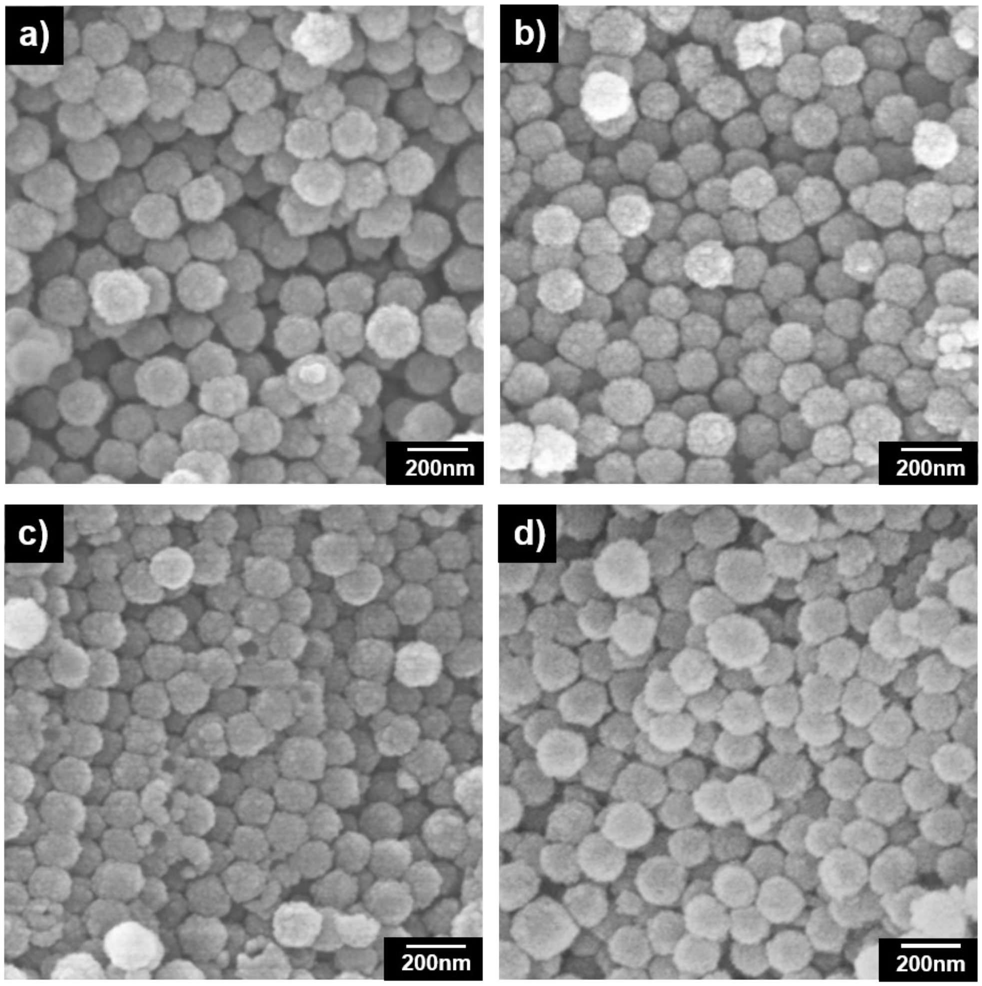


**Fig. S2** Field emission scanning electron microscope (FE-SEM) images of a) HNPs, b) Mg-doped HNPs, c) Zn-doped HNPs, and d) Fe-doped HNPs.

**3. EDS mapping of various metal-doped HNPs.**

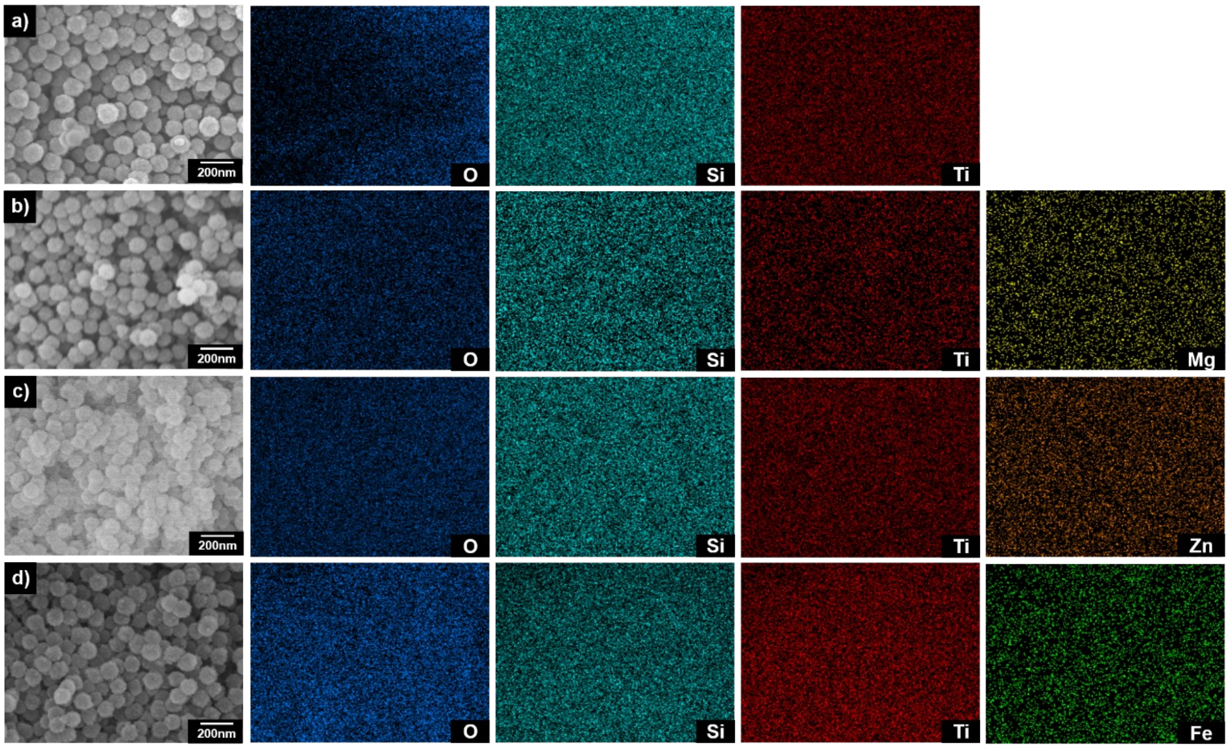


**Fig. S3** EDS mapping data of a) HNPs, b) Mg-doped HNPs, c) Zn-doped HNPs, and d) Fe-doped HNPs.

## 4. XPS spectrum analysis of O 1s, Si 2p, and Ti 2p of various metal-doped HNPs.

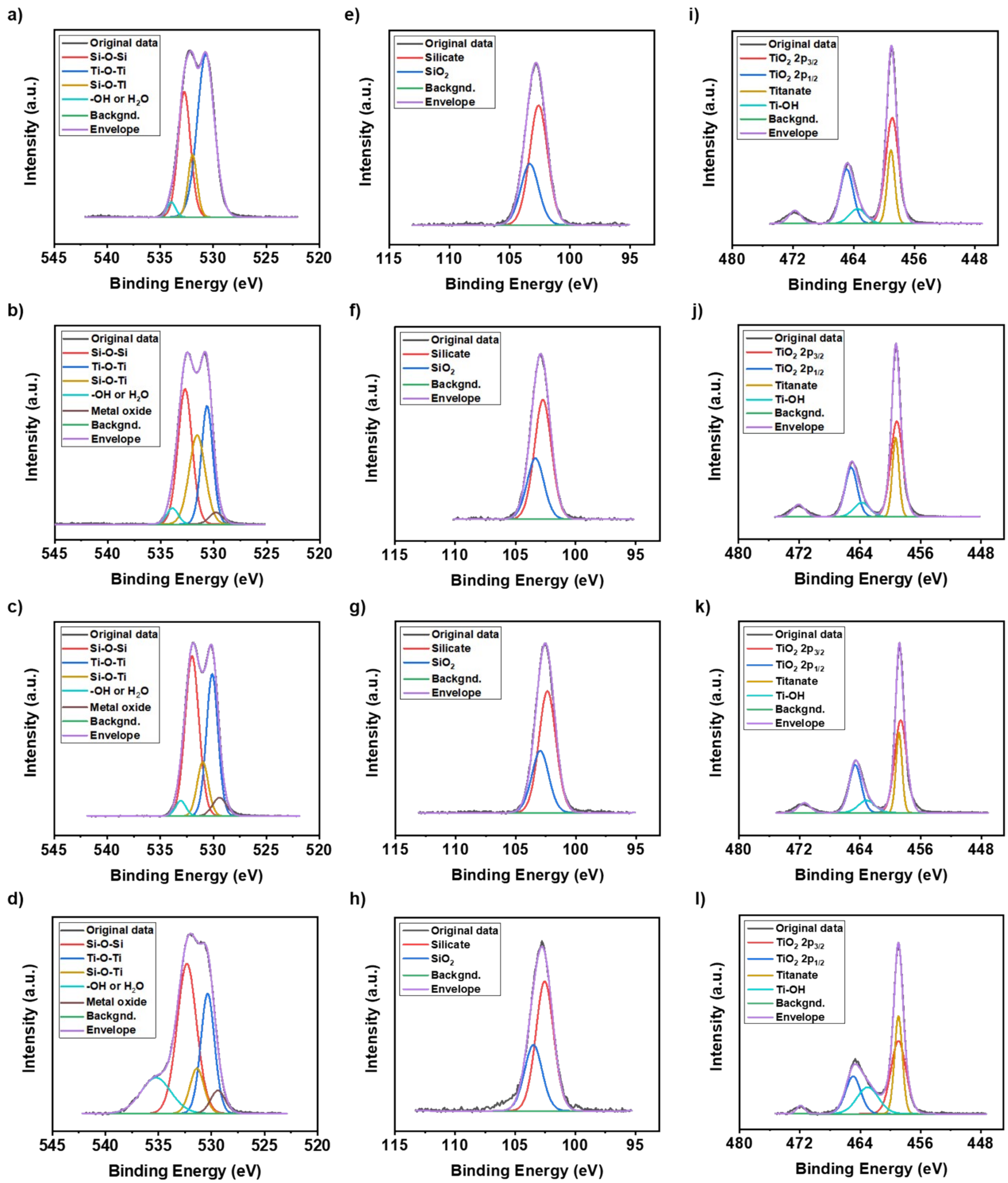


**Fig. S4** XPS O 1s spectra of a) HNP, b) Mg-HNP, c) Zn-HNP, d) Fe-HNP, respectively. XPS Si 2p spectra of e) HNP, f) Mg-HNP, g) Zn-HNP, h) Fe-HNP, respectively. XPS Ti 2p spectra of i) HNP, j) Mg-HNP, k) Zn-HNP, l) Fe-HNP, respectively.

**5. Shear viscosity of various metal-doped HNPs as a function of shear rate.**

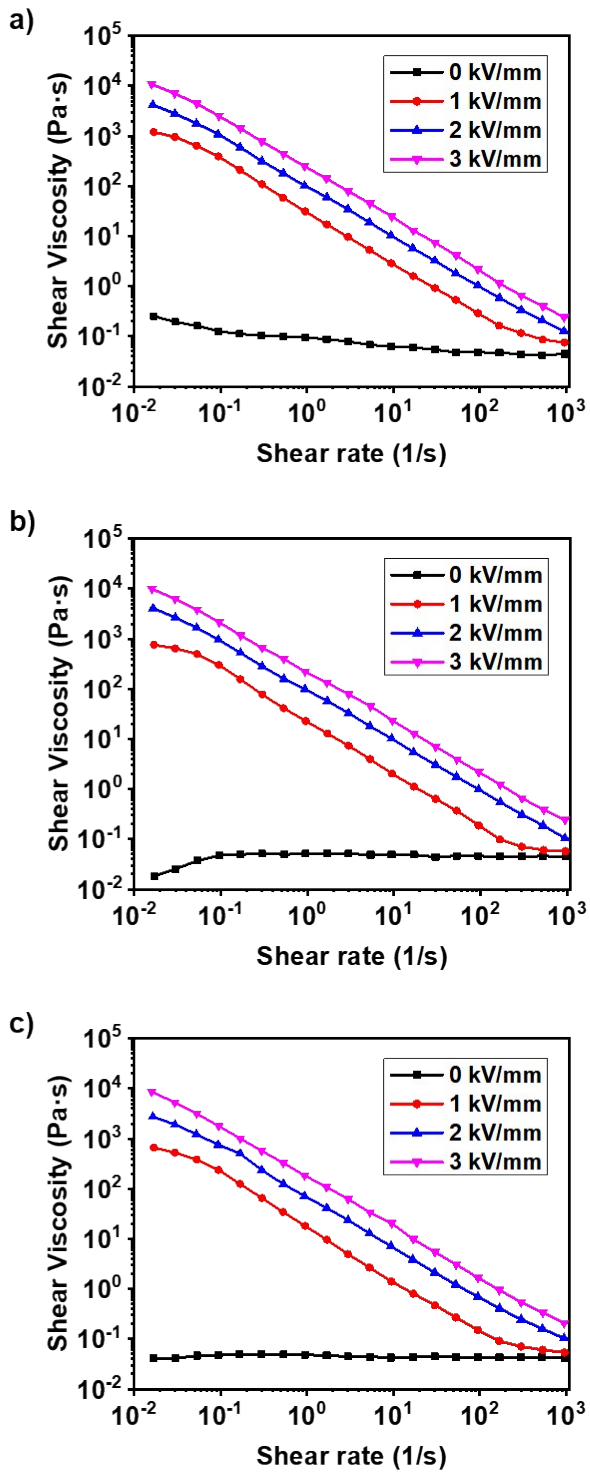


**Fig. S5** Shear viscosity of a) Mg, b) Zn, and c) Fe-doped HNP-based ER fluids as a function of shear rate.

**6. Relative permittivity of soybean oil .**

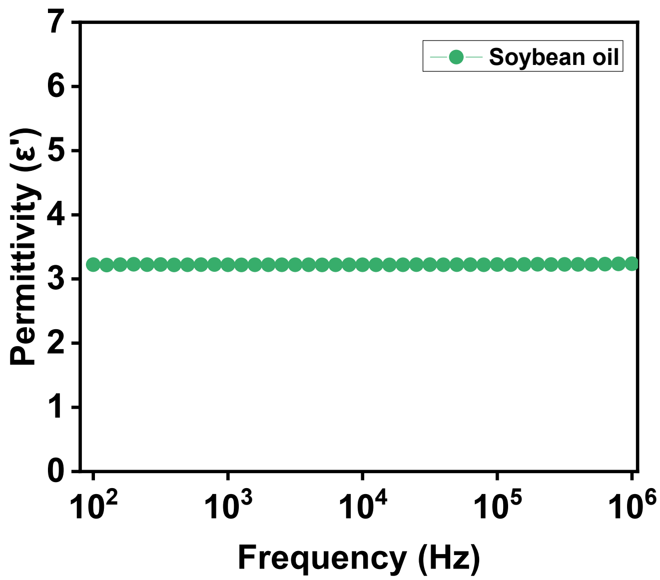


**Fig. S6** The permittivity as a function of electric field frequency for soybean oil.

**7. Optical microscope images of the structural transition of HNP-, Mg-doped HNP- and Zn-doped HNP-based ER fluids.**

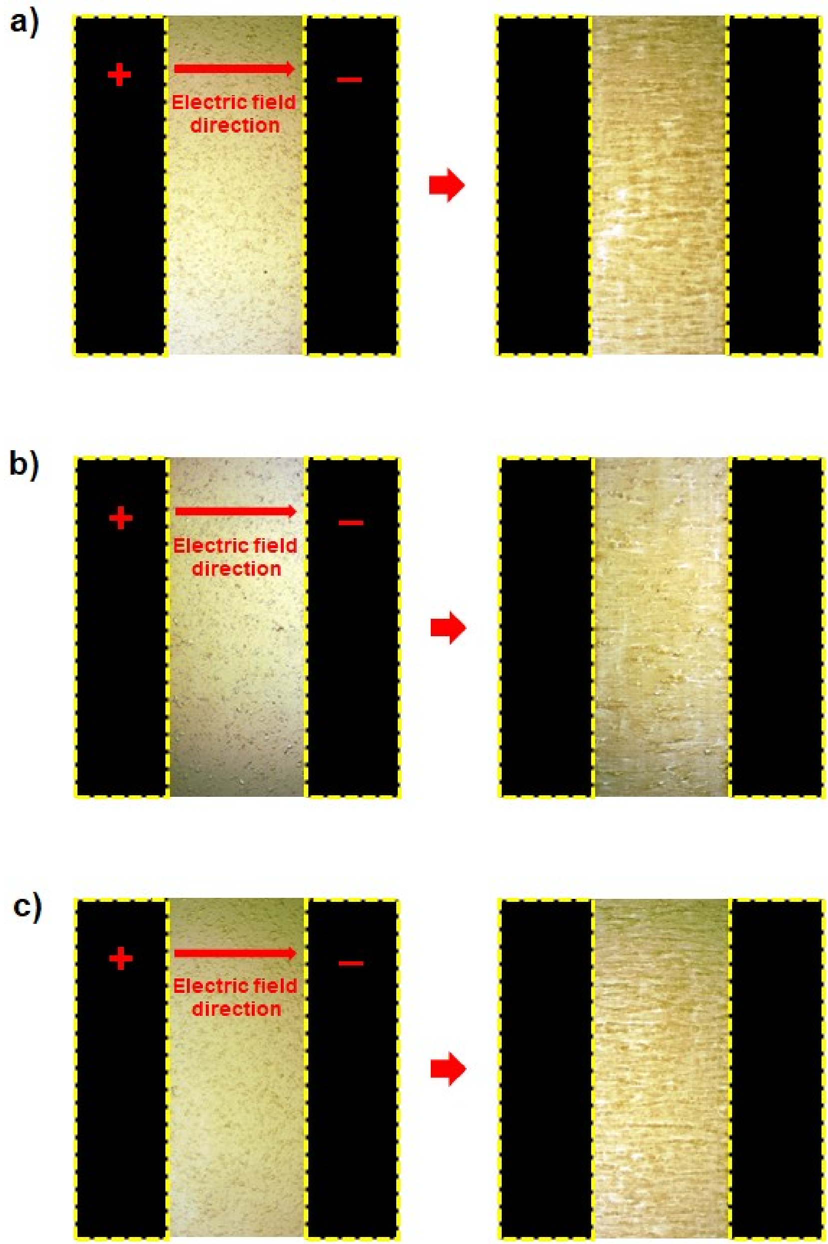


**Fig. S7** Optical microscope images of a) HNP-, b) Mg-doped HNP-, and c) Zn-doped HNP-based ER fluids under the external electric field of 0.5 kV $mm^{-1}$. The gap between two electrodes was fixed as 1.0 mm.

**8. Physical parameters of HNPs and metal-doped HNPs-based ER fluids.**

**Table S1**. Physical parameters and sedimentation velocity of HNPs and metal-doped HNPs in soybean oil.

| Samples | Particle diameter[a] (nm) | Particle density[b] ($g\ cm^{-3}$) | Fluid density[c] ($g\ cm^{-3}$) | Fluid viscosity[c] (Pa s) | Sedimentation velocity[d] ($m\ s^{-1}$) |
|---|---|---|---|---|---|
| HNPs | 115 | 1.52 | 0.92 | 0.054 | $8.288\times10^{-13}$ |
| Mg-doped HNPs | 115 | 1.61 | 0.92 | 0.054 | $9.571\times10^{-13}$ |
| Zn-doped HNPs | 115 | 1.81 | 0.92 | 0.054 | $1.226\times10^{-12}$ |
| Fe-doped HNPs | 115 | 1.85 | 0.92 | 0.054 | $1.289\times10^{-12}$ |

[a] The average diameter of the HNPs and the metal-doped HNPs were determined by TEM analysis.

[b] The density of the HNPs and the metal-doped HNPs were measured by pycnometry at 24 °C.

[c] Soybean oil was used as the dispersing medium. Density and viscosity values of soybean oil were taken from previously published work.[1,2]

[d] The sedimentation velocity was calculated using Stokes' equation.

## 9. References

1 H. Noureddini, B. C. Teoh and L. Davis Clements, *J. Am. Oil Chem. Soc.*, 1992, **69**, 1184–1188.

2 H. Noureddini, B. C. Teoh and L. Davis Clements, *J. Am. Oil Chem. Soc.*, 1992, **69**, 1189–1191.