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Interplay between Microstructure and Heating Properties of Semi-crystalline Polymer Nanocomposites

Author: Laura Ea[1]

Co-authors: Florent Dalmas [1]; Lise-Marie Lacroix [2]; Gildas Coativy [3]; Guilhem Baeza [4]

[1] *Matéis - INSA Lyon*

[2] *LPCNO - INSA Toulouse*

[3] *LGEF - INSA Lyon*

[4] *IMP - Univ Jean Monnet*

Magnetic hyperthermia (MH) arises from heat dissipation by magnetic nanoparticles (MNPs) exposed to a high-frequency magnetic field. This phenomenon has garnered significant attention due to its promising applications in biomedical engineering, materials science, and chemistry.[1,2] While heat generation is often associated with magnetic hysteresis losses, which are primarily determined by the intrinsic properties of the nanoparticles, our recent findings highlight the crucial role of the surrounding medium.[3]. In this work, we aim to transcend empirical approaches by developing a unified framework to quantify and predict MH phenomena based on diverse parameters contributing to heat generation. In this context, we embedded iron oxide nanoparticles in polypropylene (PP), a semi-crystalline polymer, of various viscosities (*i.e.* with zero shear viscosities varying between 55 and 7800 Pa s) and investigated the role of the host polymer viscoelastic properties and their influence on the heating efficiency of the MNPs. We used experimental probes such as *in situ* Small-Angle X-rays Scattering (SAXS) performed under a high-frequency magnetic field combined with direct thermal imaging of the composites to track the motion of the MNPs and follow their heating behaviour. Figure 1 shows the influence of the MNPs host matrix viscosity on the kinetics of dipolar column formation and their impact on the global specific absorption rate (SAR in W g^{-1}). Results from *in situ* SAXS indicated that faster MNPs translational motion is detected in low viscous nanocomposites, which results in a structure at equilibrium that is reached at short times. Whereas, highly viscous matrices slow down the MNP translational motion which tends to reach structure at equilibrium at longer times. Overall, our study highlights the multiple heating mechanisms involved in MH with the aim of corroborating computational models[4] with new *in situ* SAXS experimental insights.

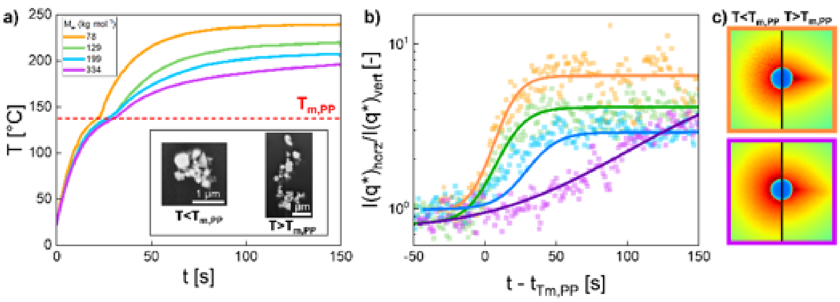

Figure 1: **a)** Temperature vs. time of the nanocomposites submitted to a high frequency magnetic field (800 kHz, 5 mT). The inset corresponds to Scanning Electron Microscopy images displaying the structural organisation of the MNPs. **b)** Degree of anisotropy vs. time showing the kinetics of MNPs dipolar chains formation. **c)** 2D SAXS patterns of the less viscous matrix (orange square) vs. highest viscous matrix (purple square).

References

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