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Disruption of Insulin Amyloid Fibrils Using Nanoparticles and External Magnetic Fields: Comparative Effect of Pulsed and Rotating Magnetic Fields

Author: Peter Kopcansky[1]

Co-authors: Katarína Šipošová [1]; Matus Molcan [1]; Andrzej Skumiel [2]; Jakub Musiał [2]; Viktor I. Petrenko [3]; Oleksandr Tomchuk [4]; Safarik Ivo [5]

[1] *Institute of Experimental Physics SAS, Slovak Academy of Sciences*

[2] *Chair of Acoustics, Faculty of Physics and Astronomy, Adam Mickiewicz University*

[3] *BCMaterials, Basque Center for Materials, Applications and Nanostructures; 2nd: Ikerbasque, Basque Foundation for Science*

[4] *ISIS Neutron and Muon Source, Science and Technology Facilities Council*

[5] *Institute of Experimental Physics SAS, Slovak Academy of Sciences; 2nd: Department of Nanobiotechnology, ISBB, Biology Centre, CAS*

The high stability of amyloid fibrils presents a challenge in treating protein misfolding diseases. Since they are resistant to enzymatic clearance, physical disruption via magnetic nanoparticles offers a promising alternative. This study investigates the anti-amyloid efficiency of precipitated acid ferrofluid (PFF), nanodiamonds (NDs), ferrofluid-modified nanodiamonds (FF-NDs), and a mixture of NDs with microwave-synthesized magnetite (ND/MW-mag mixture) under two distinct magnetic field conditions: a high-intensity pulsed magnetic field (PMF, 7.5 T) and a high-frequency rotating magnetic field (RMF, 7.5 kA/m). SAXS measurements of the FF-NDs system indicate the binding of 3 nm NDs onto 12 nm MNPs. We assume that NDs act as "thermal bridges"; due to diamond's exceptional conductivity, they rapidly conduct energy to the fibril surface, causing localized destabilization more effectively than simple magnetic heating. Our results (Fig. 1), obtained via ThT assay and AFM, show that while nanoparticles alone initiate fibril disassembly, external magnetic fields enhance disassembly. The PMF treatment was particularly effective at lower nanoparticle concentrations (0.25 mg/mL). In this regime, the combination of mechanical torque and localized thermal transfer appears to be the dominant factors in breaking down the cross-β sheet framework.

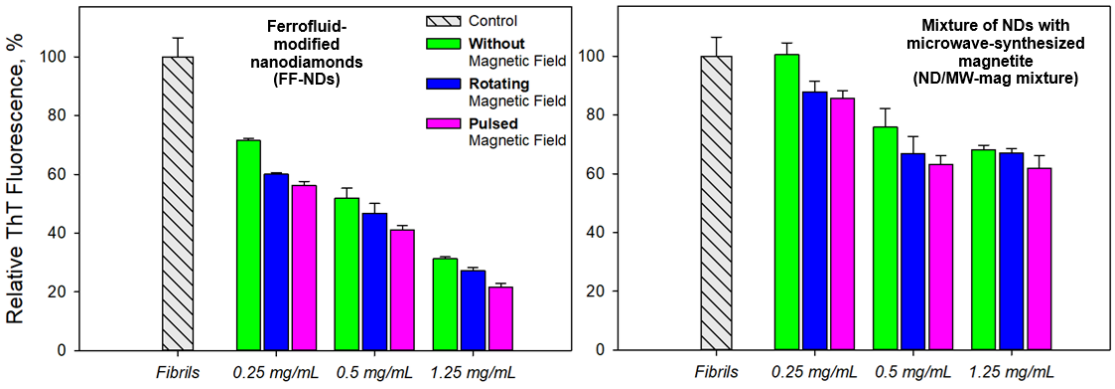

Figure 1: Anti-amyloid destructive activity of FF-NDs and the ND/MW-mag mixture monitored by ThT fluorescence assay.

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Poster