Magnesium Ferrite for Neural Applications

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Statement of Purpose: Nerve regeneration and total recovery of nerve sensory and motor functions have been an issue in regards to the treatment of neurons after accident related injury or degenerative disease. Electrospun fibers have been explored as tissue engineering scaffolds for repairing these defects in both the central and peripheral nervous systems. Studies have shown that these fibers provide guidance cues for neurite outgrowth in the direction of alignment. Additionally, metal ions have been used to moderate cell attachment and affect neural differentiation. Neurotrophic magnesium promotes tissue regeneration and shows potential as a soluble mediator for repairing damage to the central nervous and peripheral nervous systems. Magnetic nanoparticles have also been documented in their application for cell mechanosensitive receptor manipulation to induce cell differentiation. For these purposes magnesium ferrite, a ferromagnetic spinel ferrite is suitable to provide the magnetic and metal ion attributes favorable for potential nerve repair. This study aims to investigate the feasibility of encasing magnesium ferrite particles in a polymeric, electrospun fibrous scaffold for neural applications.

Methods: Magnesium Ferrite particles were synthesized via sol-gel method. An aqueous mixture of stoichiometric molar proportion of $Mg(NO_3)_2 \cdot 6H_2O$ and $Fe(NO_3)_3 \cdot 9H_2O$ was prepared citric acid was dissolved into the mixture such that molar ration of citric acid to metal nitrate was unity. The mixture was stirred for 10 hours at 60℃ then abruptly heated to 800℃. The sol transformed to a black sticky gel and was dried at 200℃ for 2 hours. The dried gel was ground and calcined for 2 hours.

Scanning electron microscopy, physical property measurement system (PPMS), and x-ray diffraction were used to characterize the structural, magnetic, and morphological properties of the material.

PCL and chitosan solutions were prepared separately and combined shortly before the electrospinning procedure. A 10% PCL (w/w) solution was synthesized by dissolving the polymer in Tetrafluro ethanol (TFE). Polycaprolactone was added to TFE and left on magnetic stirrer to mix overnight. Depolymerized chitosan is weighed and used to create a 10% chitosan solution (w/w) with distilled water as its solvent. When combining PCL and chitosan polymer solutions, 6 ml of each ratio is calculated, weighed, and stirred for less than 5 min. Magnesium ferrite is added to the PCL/Chitosan solution at different rations and stirred for 30 min. The solution is electrospun into a fibrous mats.

Results: XRD spectra were used to verify spinel structure of $MgFe_2O_4$. Peaks indicated the formation of magnesium ferrite crystallites and no Fe_2O_3 was detected.

SEM images of particles show the particle size distribution. The mean size of the particles was 0.5 micrometers. Particles were also seen to be slightly agglomerated.

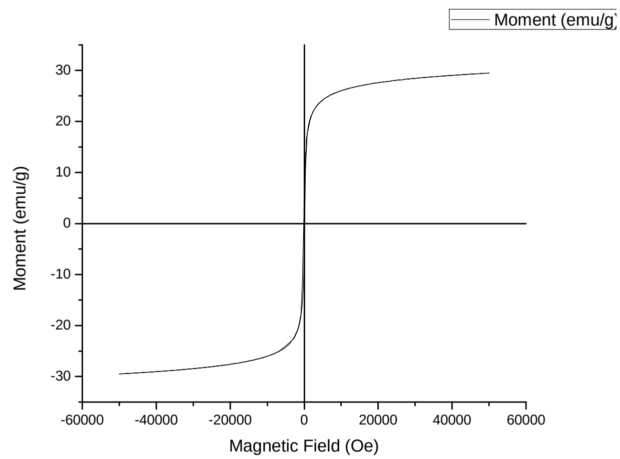

Figure 1. Magnetic hysteresis loop at 27℃

Figure 1 shows the magnetization versus applied field curve for the magnesium ferrite. The M-H loops at 300K show magnetic saturation, M_s, was achieved at 29.4 $emu\ g^{-1}$, indicating superparamagnetic property.

Conclusions: Magnesium ferrite particles were successfully synthesized via sol gel method. The particles possess crystalline structure and superparamagnetic properties. Electrospun fibers can be created using these particles for the creation of ferromagnetic structures. The $MgFe_2O_4$ particles and ferromagnetic structures could have potential for neural applications.

References:

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