Incorporation of magnetite nanoparticles in chitosan-based scaffolds for magnetic hyperthermia therapy and bone regeneration.

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There is a high demand to develop new strategies to treat malignant bone tumors and, simultaneously, to regenerate bones defects produced by the tumor resection. Multifunctional bioactive 3-D scaffolds can be a potential approach to fulfill this urgent need. In this work, it is proposed to develop magnetic chitosan-based scaffolds, through freeze-drying, with potential to simultaneously promote bone regeneration and kill residual cancer cells by thermal hyperthermia. Chitosan was selected as main matrix due to its properties suitable for bone tissue engineering, such as biocompatibility, antibacterial, and osteogenic behaviour. Although, it possesses poor mechanical properties, showing low elastic moduli [1]. As Fe_3O_4 NP have been highly explored in biomedical fiel as heat mediators in magnetic hyperthermia therapy, pristine Fe_3O_4 NP produced by co-precipitation could be incorporated in chitosan-based scaffolds to increase their mechanical strength. Therefore, different chitosan concentrations were assessed (1, 1.5, 2 and 2.5% w/v) and the effect of Fe_3O_4 NP incorporation on scaffolds properties were evaluated.
The results show that scaffolds porosity decreases as chitosan concentration increases, although a porosity around ~95% and ~83% were achieved for chitosan at 2 and 2.5 % w/v respectively. On the other side, scaffolds with higher Young Modulus and enhanced toughness were attained for 2.5% w/v since scaffolds with lower porosity exbibits higher mechanical response, improving the scaffold integrity. Synthetized spherical Fe_3O_4 NP with sizes around 9 nm, and with a Specific Loss Power of 98 W/g were then incorporated (10 and 20 % w/w) in 2.5 and 3% w/v chitosan matrix producing magnetic scaffolds. A significant reduction of porosity was only observed for chitosan at 3% w/v with 20% w/w NP (~65.5%). Although, mechanical properties were highly enhanced with an increase from 0.68 to 2 MPa for Young Modulus and from 16.5 to 41.7 MPa for toughness, comparing to pristine chitosan scaffolds. Furthermore, this incorporation did not significantly affect the elongation properties (~23.1%). In general, the results confirm the ability to produce highly porous scaffolds with freeze drying technique, even for higher chitosan concentrations, and the incorporation of Fe_3O_4 NP specially at 20% w/w improves chitosan scaffolds mechanical properties without compromising the porosity. Therefore, these magnetic scaffolds, could have a great potential to address simultaneously the regeneration of bone defect and eradicate residual cancer cells by thermal hyperthermia.

References

[1] G. Turnbull, J. Clarke, F. Picard, P. Riches, L. Jia, F. Han, B. Li and W. Shu, Bioact. Mater., 2018, 3, 278–314

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