NOVEL INJECTABLE, SELF-GELLING HYDROGELMICROPARTICLE COMPOSITES FOR BONE REGENERATION CONSISTING OF GELLAN GUM AND CALCIUM AND MAGNESIUM CARBONATE MICROPARTICLES

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[Engineering of Biomaterials 138 (2016) 111]

Introduction

The suitability of hydrogel biomaterials for bone regeneration can be improved by incorporation of an inorganic phase in particle form, thus maintaining hydrogel injectability. In this study, carbonate microparticles containing different amounts of calcium (Ca) and magnesium (Mg) were added to solutions of the anionic polysaccharide gellan gum (GG) to crosslink GG by release of Ca²⁺ and Mg²⁺ from microparticles and thereby induce formation of hydrogel-microparticle composites. It was hypothesized that increasing Mg content of microparticles would promote GG hydrogel formation. The effect of Mg incorporation on cytocompatibility and cell growth was also studied.

Materials and Methods

Microparticles were formed by mixing Ca²⁺ and Mg²⁺ and CO₃²⁻ ions (TABLE 1). Microparticle groups A-E were characterized physiochemically by FTIR, XRD, Raman, SEM, TEM, SAED and ICP-OES and subsequently mixed with GG solution to form hydrogel-microparticle composites, which were characterized by µCT, rheometry and biologically using MG63 osteoblast-like cells.

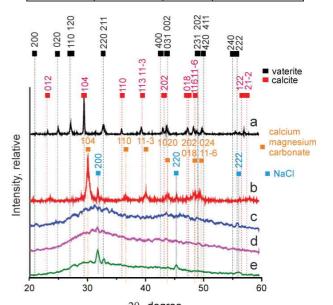
Results and Discussion

The elemental Ca:Mg ratio in the mineral formed was similar to the Ca:Mg ratio of the ions added. In the absence of Mg, vaterite was formed. At low Mg content, calcium magnesium carbonate (CMC) was formed (FIG. 1). Increasing the Mg content further caused formation of amorphous mineral. Microparticles of vaterite and CMC did not induce GG hydrogel formation, but addition of Mg-richer amorphous microparticles induced gelation (FIG. 2) within 20 minutes. Microparticles were dispersed homogeneously (FIG. 3.) Cells were cultured in

eluate from composites and on the composites themselves. All composites were cytocompatible. Cell growth was highest on composites containing particle group C.

TABLE 1. Concentrations of solutions used in this study. Equal volumes of Ca²⁺/Mg²⁺ solution and CO₃²⁻ solution were mixed to form microparticles.

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	Micro- particle group	Conc. in Ca ²⁺ /Mg ²⁺ solution		Conc. in CO ₃ ²⁻ solution
		CaCl ₂	MgCl ₂	Na₂CO₃
		(M)	(M)	(M)
	Α	0.333	0	0.333
	В	0.250	0.083	0.333
ĺ	С	0.167	0.167	0.333
	D	0.083	0.250	0.333
ĺ	Е	0	0.333	0.333



20, degree FIG. 1. XRD analysis of microparticles.



FIG. 2. Images of hydrogel-microparticle composites.

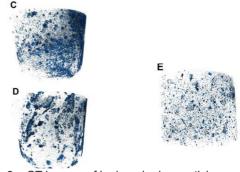


FIG. 3. μ CT images of hydrogel-microparticle composites.

Conclusions

Carbonate microparticles containing a sufficient amount of Mg induce GG hydrogel formation, resulting in injectable, cytocompatible composites.

Acknowledgments

FWO, BOF UGent (both Belgium) and the ERA-Net Rus Plus project "Intelbiocomp" are acknowledged.