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Effect of Magnesium Hydroxide Nanoparticles with Rod and Plate Shape on Mechanical and Biological Properties of Poly(*L*-lactide) Composites

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Abstract: Two kinds of magnesium hydroxide ($Mg(OH)_2$) rods (Mg-Rod, 150 and 350 nm in size) and plates (Mg-PL, 60 and 300 nm) were prepared, and blended with poly(*L*-lactide) (PLLA) to obtain PLLA/$Mg(OH)_2$ composites to investigate the effect of the shape and size of $Mg(OH)_2$ particles. The structure, morphology, pH change, thermal and mechanical properties, cytotoxicity, and inflammation of $Mg(OH)_2$ control and PLLA/$Mg(OH)_2$ composites were evaluated. PLLA/Mg-Rod150 (30%) composite showed a 50% higher tensile strength and a 45% improved modulus as compared with PLLA/Mg-PL300 30% composite. Although Mg-Rods displayed similar cell viability (above 80%) as compared to Mg-PLs, the expression levels of TNF-α from Mg-PL60 gradually increased with increasing concentrations from 1 to 300 μg. This indicates that Mg-PL60 had a potential cytotoxicity due to endocytosis. In addition, the byproduct of PLLA/Mg-Rods composite was more effectively neutralized than that of the PLLA/Mg-PLs composite, but cell viability and the expression levels of TNF-α were similar. Therefore, the use of our PLLA/Mg-Rod composite system would be a promising strategy to prevent the current fatal problems in biomedical applications including biodegradable implants such as stents.

Keywords: poly(*L*-lactide), magnesium hydroxide, shape, mechanical property, inflammation.

Introduction

Poly(*L*-lactide) (PLLA) has the characteristics of being degradable and absorbable in human body, and recently attracted considerable attention as a biomaterial.[1-4] PLLA was degraded by chain hydrolysis and enzymes and was completely absorbed in the human body through the Krebs cycle.[5,6] However, acidic materials are produced during the degradation of PLLA, thereby leading to cytotoxicity and inflammation response.[7-9] Andersson *et al.* verified the inflammation response through a homogeneous hydrolytic chain cleavage mechanism and confirmed to suppress inflammation response by paclitaxel-loaded PLLA microspheres.[10] Kontio *et al.* reported that PLLA resulted in a chronic inflammatory reaction in an *in vivo* experiment.[11]

Many studies have been conducted to prevent cytotoxicity and inflammation response induced during polylactide degradation.[12-14] Vogt *et al.* reported that intravascular restenosis can be prevented by using a polylactide stent containing paclitaxel.[12] Further research is currently being conducted to prevent polylactide inflammation using other drugs such as antitumor agents, which however can cause side effects in the human body.[13,14] In our previous study, we prepared magnesium hydroxide ($Mg(OH)_2$) for neutralizing acidic materials, which are generated during the degradation of polylactide, and the cell cytotoxicity and inflammation response can be effectively suppressed by pH neutralization effect.[15]

However, it is known that the mechanical properties are reduced because of the immiscibility between PLLA and ceramic magnesium hydroxide. Especially, the irregular plate crystal structure of magnesium hydroxide has negative effects on its mechanical properties.[16,17] Many studies have carried out to control the crystal structure of magnesium hydroxide.[18-20] Dehong *et al.* reported that magnesium hydroxide can be grown in the form of rods through a co-precipitation process.[18] Henrist *et al.* stated that different types of magnesium hydroxide can be grown by suitably adjusting the base

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