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Novel Composite for Maxillofacial Surgery

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Introduction

New bone composites that promote hydroxyapatite precipitation have potential to show superior bone bonding compared to conventional PMMA bone cements. This would make them more suitable for osteosynthesis plate fixation in fragile bone areas that cannot be fixed with screws[1,2]. The composite must additionally have high degree of monomer conversion to ensure low risk of toxic monomers release[3] and high strength and toughness to increase the durability of the fixation.

Aim

The study aim was to develop a composite and compare its monomer conversion (MC), biaxial flexural strength (BFS), fracture toughness (K_{IC}), and apatite forming ability with that of commercial materials.

Materials and Method

The experimental composite (Exp) consisted of 30 wt% methacrylate monomers with chemical curing initiators, combined with 70 wt% powder. The powder phase contained 57.5 wt% glass fillers, 20 wt% fibres to enhance toughness, and 5% polylysine as an antibacterial agent. Furthermore, 10 wt% reactive monocalcium phosphate monohydrate (MCPM) and 7.5 wt% tristrontium phosphate (TSrP) were added to promote surface hydroxyapatite precipitation. Commercial PMMA (Simplex®) and bone composite (Cortoss®) were used for comparison. MC was measured through FTIR (n=3). BFS and K_{IC} of set materials were measured after 24 hours immersion in simulated body fluid (SBF)(n=8). Fracture surfaces were investigated using SEM. Data were then analysed using one-way analysis of variance (ANOVA), and Bonferroni's test (p=0.05). Additionally, the apatite forming ability was assessed under SEM and EDX after the specimens were immersed in SBF for 1 week.

Results

The experimental composite showed significantly higher MC, BFS, and K_{IC} than Cortoss but not Simplex (Figure 1). SEM demonstrated newly formed calcium phosphate crystals (CaP) had replaced the ground reactive fillers (Figure 2). These and the fibres may have helped retard crack propagation, resulting in the higher toughness. Additionally, the experimental bone composite promoted calcium-deficient hydroxyapatite precipitation on the specimen's surface (Figure 3.)

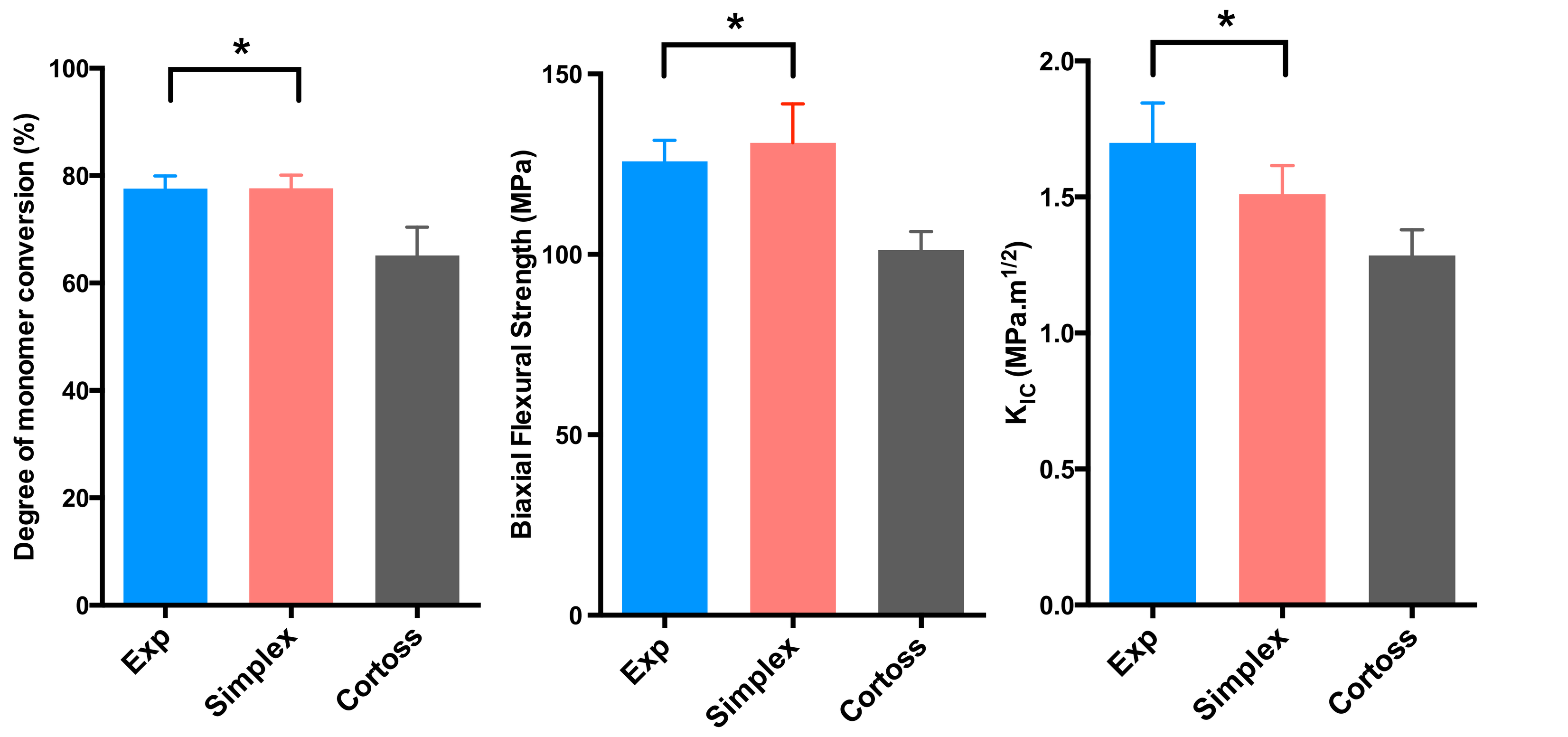

Figure 1 MC, BFS, and K_{IC} of each group, stars indicate no significant difference (p >0.05). Error bars are 95% CI.

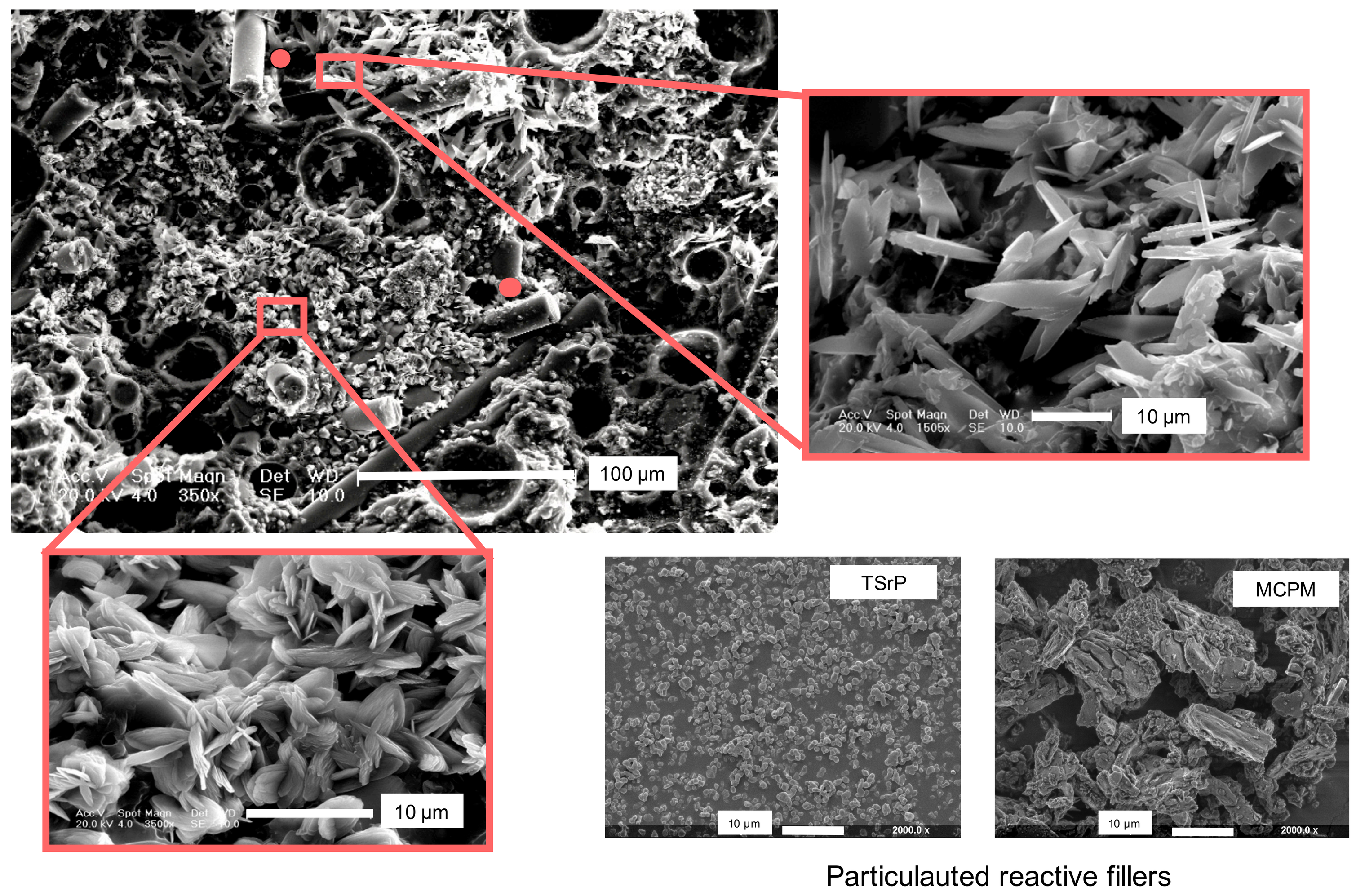

Figure 2 Fracture surface of experimental composite. Pulled-out fibres (circles), and newly formed of CaP (square) were seen.

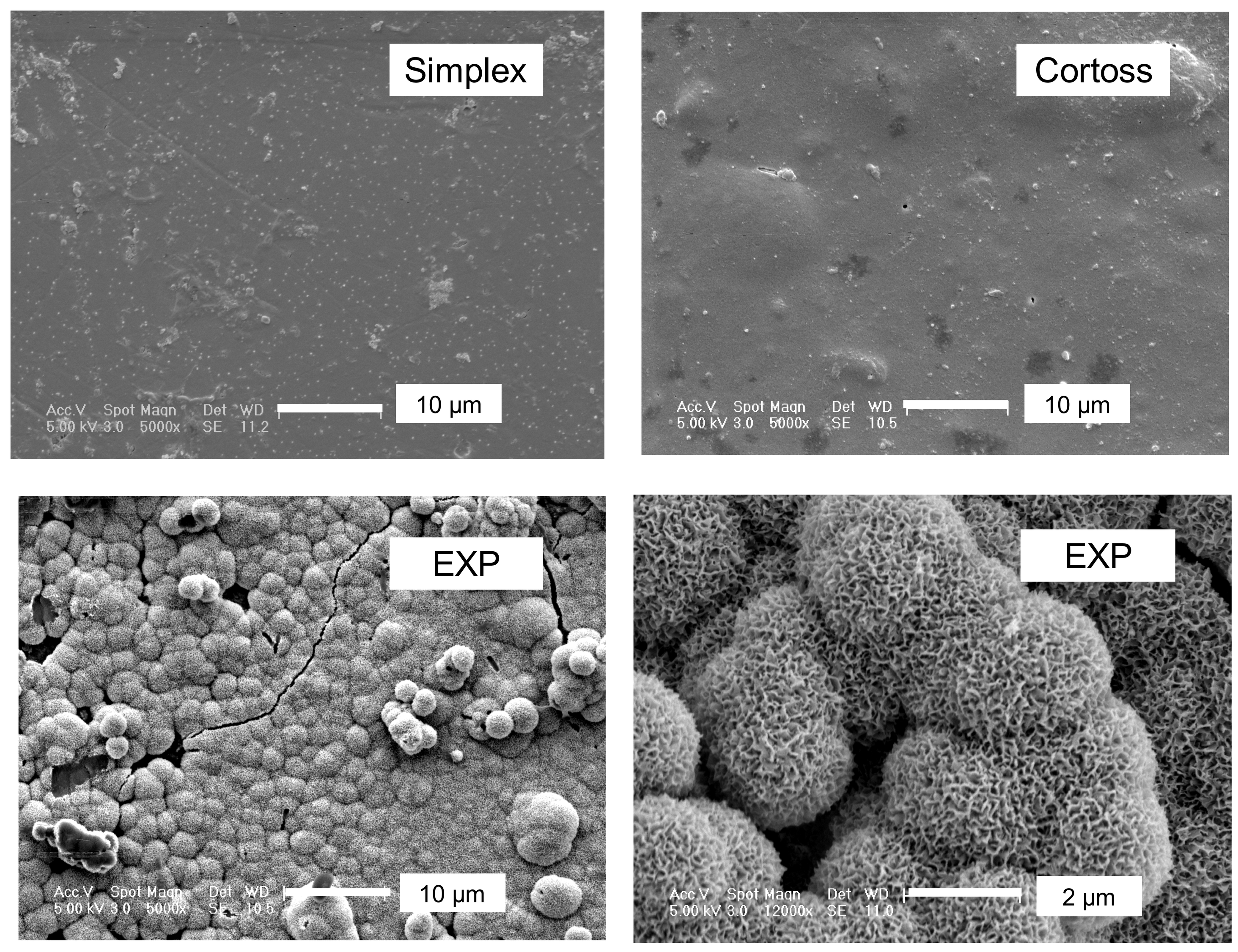

Figure 3 Apatite layer can be seen only in the experimental composite. EDX detected the presence of smalls amount of Na^{+}, Mg^{2+} and Cl^{-} and a molar Ca/P ratio of 1.46 in the precipitated surface layer.

Conclusions

Experimental composite had MC and strength comparable or higher than the commercial products. These may ensure low risk of monomer release and high mechanical performance. Furthermore, the composite encouraged surface HA precipitation, which is known to promote *in vivo* bone bonding. This new composite is therefore a promising material for maxillofacial surgery applications.

References

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