

Evaluation of the Cohesiveness of Injectable Ca-aluminate Based Materials in Water and Simulated Body Fluid During Curing

H. Spengler¹, L. Hermansson^{1,2} and H. Engqvist^{1,2}

¹ *Doxa AB, Axel Johanssonsgata 4-6, 754 51 Uppsala, Sweden.* ² *Materials Science Department, The Angstrom Laboratory, Uppsala University, Box 534, 751 21 Uppsala, Sweden.*

INTRODUCTION: Recently much attention has been paid cements for stabilizing osteoporotic vertebral compression fractures. The cements are injected into the compressed vertebrae. Most procedures are performed using PMMA, which however has some negative feature, e.g. high curing temperature and low osseointegration. The drawbacks with PMMA can be overcome by using a non-resorbable bioceramic calcium aluminate based material. The material is delivered as powder and liquid, which are mixed to a paste. The final properties of the hardened material are dependent on the amount of liquid added, the so-called liquid to powder ratio. When injected to the body the paste is also subjected to more liquid in the form of body fluid. Since the material is hydrophilic this can alter the surface composition of the material. There is also a possibility that chemical reactions with the body fluid can occur. This paper compares the surface reactions occurring on the calcium aluminate when injected into water or phosphate buffer solution (PBS).

METHODS: The media (i.e. water and PBS) were poured into glass containers and immersed into a 37 °C water bath for tempering. Calcium aluminate paste was prepared by adding liquid to the cement (placed in a capsule). The capsule was thereafter mechanically vibrated for one minute. One ml of cement paste was extruded into the different media at 3 minutes and 6 minutes after mixing.

Images of the extruded material in the media were taken after the material was set, i.e. > 15 minutes, using a digital camera. To analyse the composition of the “cloud” surrounding the material, the “cloud” was collected from the media using a syringe. The samples were evaporated at 110°C in glass beakers. The dried powders were collected on carbon tape and analysed with SEM/EDX.

RESULTS: In tap water a cloud is formed around the extruded material (3 minutes after mixing), see Fig. 1a. A smaller cloud forms when the cement is extruded into tap water at 6 minutes after mixing.

In PBS, the cloud seems to consist of agglomerates or flakes, see Fig. 1b.

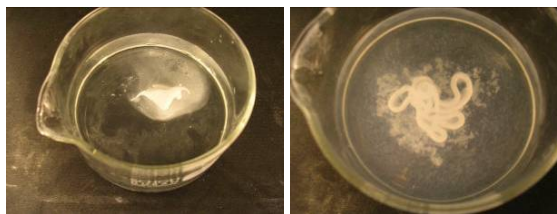


Fig. 1: Photos of calcium aluminate extruded after 3 minutes into tap water (left) and PBS (right)

Regarding the composition of the cloud, the cloud formed in water showed traces of calcium aluminate constituents, see Fig. 2a. Note especially the presence of Zr (added in the form of ZrO₂ for radio-opacity). ZrO₂ is insoluble in water and thus only appear as grains. For the test in PBS, only ions from the PBS was present in the precipitates, see Fig. 2b. Also, on the surface of the set cement P could be found, indicating apatite formation.

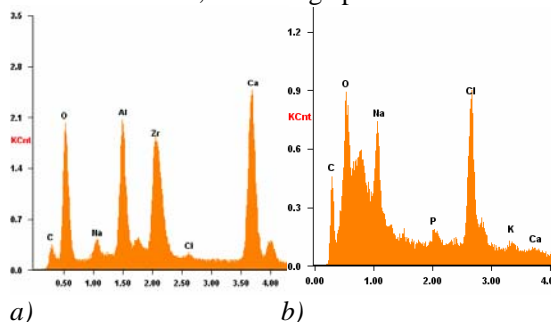


Fig. 2: Elemental composition of the collected powder (SEM/EDS) a) water and b) PBS.

DISCUSSION & CONCLUSIONS: A too high liquid to powder ratio leads to dissolution of the outer layer. In water with no flow, this results in precipitation of hydrates outside the surface. During setting the pH is increased, in the PBS this cause precipitation of salts. The salt ions in PBS form apatite at the cement surface, hindering further dissolution. The precipitations of salts or hydrates are strongly reduced when cement is injected at a later stage in the setting process. For a fully set material no precipitates can be seen.

ACKNOWLEDGEMENTS: Part of this work was financed by Göran Gustafsson Foundation for academic research.