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β-TCP platelets with high aspect ratio produced in a tubular reactor

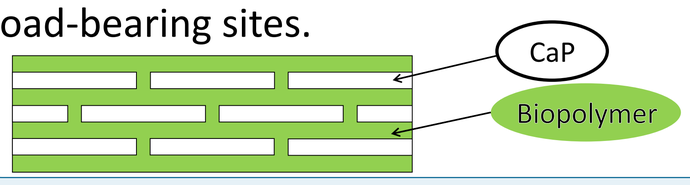
J Thuering[1,2]*, L Galea[1], M Bohner[1]

[1]RMS Foundation, Bettlach, Switzerland, [2]ETHZ, Department of Materials, Multifunctional Materials, Zürich, Switzerland,

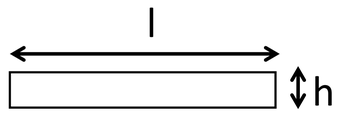
***juerg.thuering@rms-foundation.ch**

Introduction

Long-term goal:
Develop a highly structured composite as new bone substitute materials.
Such materials are supposed to combine high tensile strength and toughness, which is a precondition for application at load-bearing sites.



Ideal platelet geometry:
An ideal composite for bone substitutes should consist of ceramic platelets (CaP) in a degradable organic matrix. The ideal geometry of platelets in such a polymer was calculated by Galea et al[1]. E.g. for β-TCP platelets in chitosan:



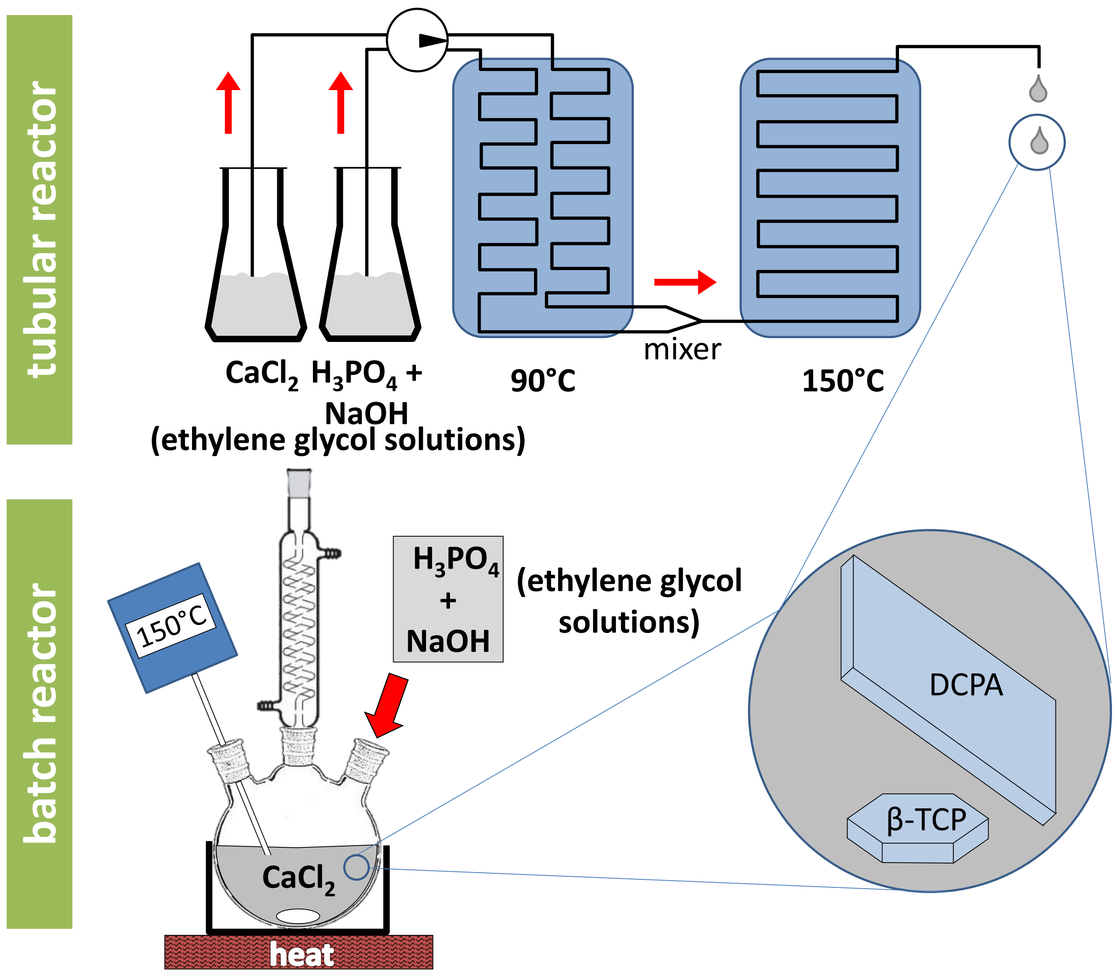
h < 350 nm
s = l/h ≈ 28

Goal of the present work:
To date, these calculations have not been confirmed experimentally because the largest aspect ratio for β-TCP platelets that could have been synthesized so far is close to 15[1]. Therefore, the goal of the present study is to produce β-TCP platelets with an aspect ratio close or even superior to 28.

Method

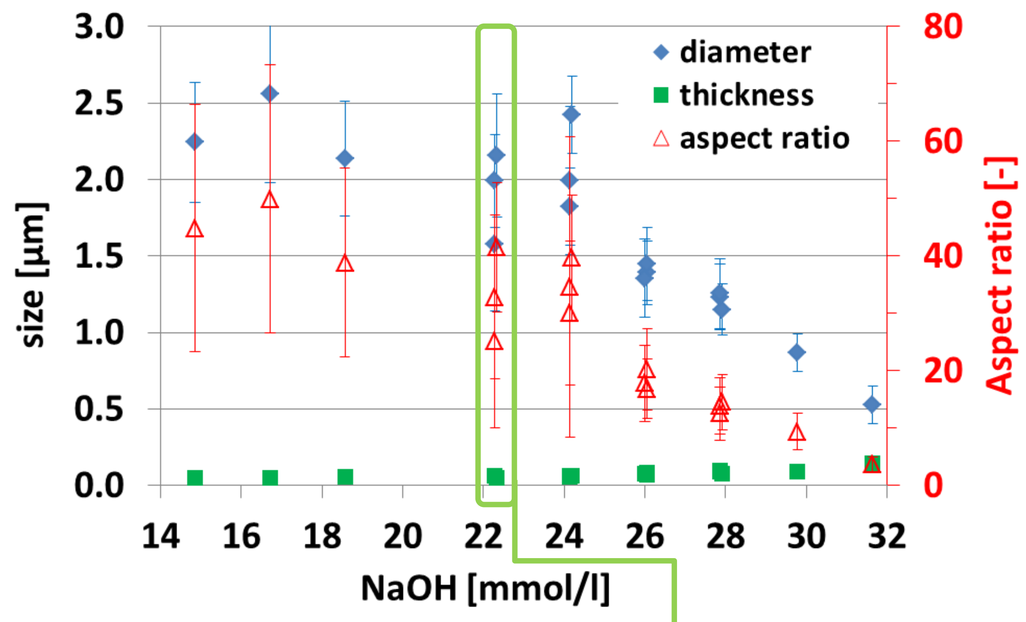
Since Galea et al[2] showed recently that the aspect ratio can be controlled by a change of pH, a systematic study was performed by varying the NaOH amount.

The experiments were carried out in a tubular reactor. For comparison with the work of Galea et al[2] a few experiments were also done in a batch reactor.



Results

By decreasing the NaOH concentration in the tubular reactor β-TCP platelets with an aspect ratio up to 50 were produced:



tubular- vs. batch reactor at c_{NaOH} = 22.3 mM:

	tubular reactor	batch reactor
Aspect ratio	33	21
Size dispersion of diameter	0.2	0.1
β-TCP content	82%	19%
DCPA content	17%	81%

Discussion & Conclusions

1. Very high aspect ratios can be obtained (s<50) by minimizing the NaOH amount in the tubular reactor.
2. A comparison of the two different production methods indicates that the β-TCP platelets, resulting from the tubular reactor, have a higher aspect ratio and size dispersion.
3. Also, both methods result in different compositions. Very reasonably, the pH of the solution in which calcium phosphates precipitated must have differed[2]. Interestingly, β-TCP platelets present a higher aspect ratio and size dispersion in more acidic conditions[2], which fits with the present data.

The main question is why different mixing conditions (tubular or batch reactor) lead to different composition - respectively to a different pH. To answer this question, additional experiments will be performed with the aim to better characterize the sequence of calcium phosphate precipitation and the precipitation conditions (e.g. pH).

References

1) L. Galea, M. Bohner, J. Thuering, N. Doebelin, T. A. Ring, C. G. Aneziris, T. Graule (2014) *Acta Biomaterialia,* (in press); 2) L. Galea, M. Bohner, J. Thuering, N. Doebelin, C. G. Aneziris, T. Graule (2013) *Biomaterials,* **34**, 6388-6401

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