Hydrogels for tissue regeneration

Timothy E.L. Douglas

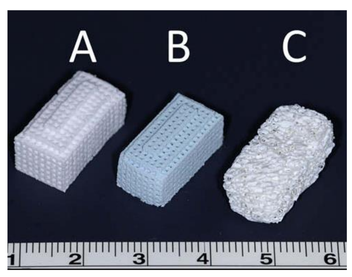
Lancaster University

Engineering Department and Materials Science Institute (MSI), Lancaster University, United Kingdom. Email:*t.douglas@lancaster.ac.uk*

Hydrogel mineralization

Combine advantages of two phases:

Gellan Gum (GG) Hydrogels



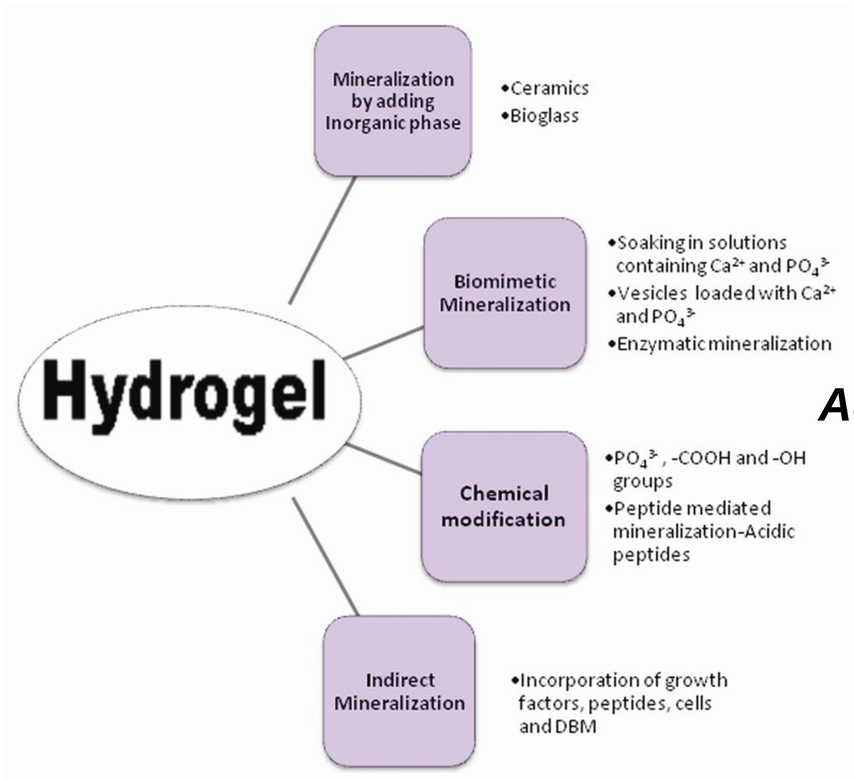
A: Tricalcium Phosphate
B: Hydroxyapatite
C: Hydroxyapatite from bovine bone

(Becker ST et al, Oral Oncology 2009)

Hydrogel
Easy incorporation
Enzymes
Particles
Flexibility

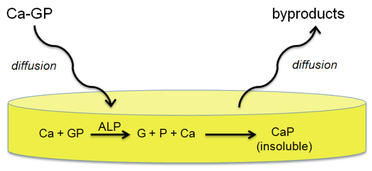
Mineral
Bioactivity
Direct bonding to surrounding bone
Mechanical reinforcement

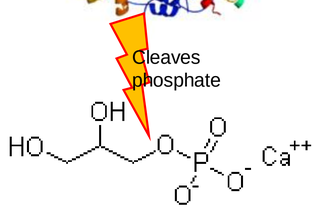
Mineralization strategies



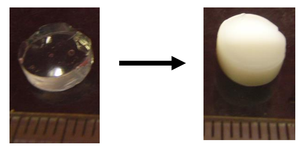
Enzymatic mineralization

Alkaline phosphatase: ALP





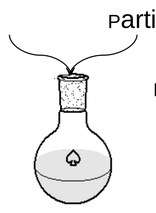
Calcium glycerophosphate (Ca-GP)

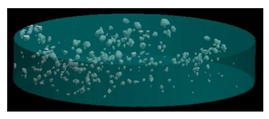


Combine advantages of Hydrogel and Inorganic phase

Addition of pre-formed particles

Hydrogel precursor (liquid)





Hydrogel forms around particles

Advantages

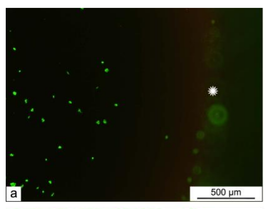
- Straightforward
- INJECTABLE

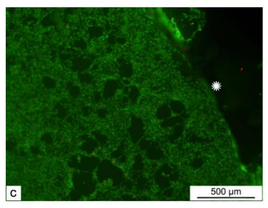
Enzymatic mineralization

Mineralized vs. unmineralized gellan gum (GG): biological significance

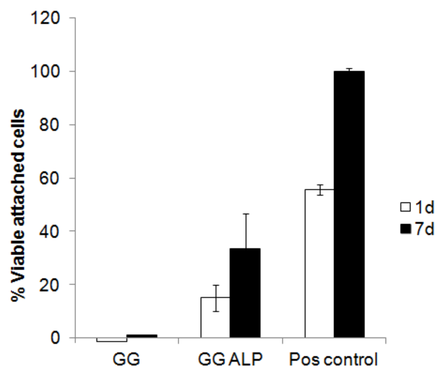
GG

GG ALP





Live-Dead cell staining



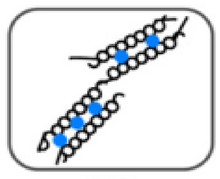
Cell proliferation

Hydrogel phase
Dissolved substances
Ca^{2+}-binding biomolecules
→ More mineralization
Antibacterial agents – *Polyphenols*

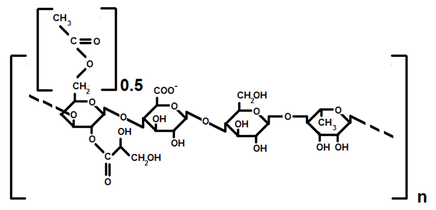
2-phase composite
Modify
Hydrogel phase
and/or
Mineral phase

Inorganic phase
Replace Ca^{2+} with other metal ions
Mg^{2+} - Cell proliferation
Zn^{2+} - Antibacterial

Addition of pre-formed particles

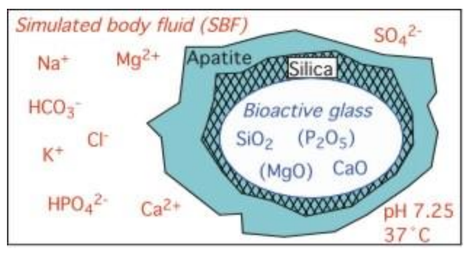


GG



Mixing

Polymer solution – gellan gum (GG)

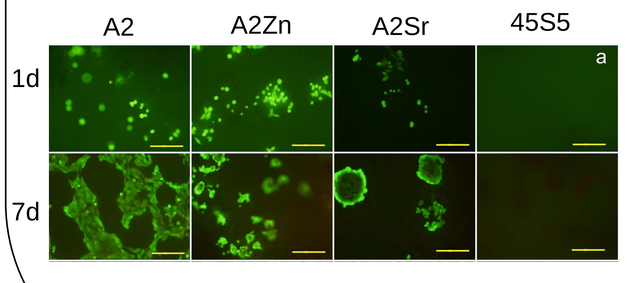


Inorganic particles - bioglass

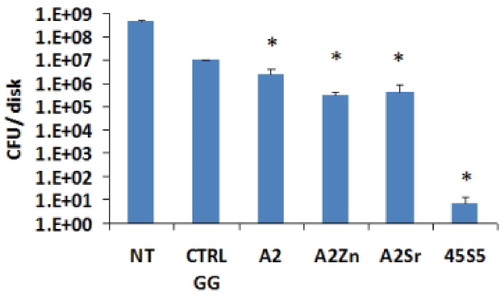
Ion release →
–Crosslinking GG
→**Hydrogel formation**
→**Injectable composite**

Glass type	Chemical composition (mol %)					
	SiO_2	CaO	P_2O_5	SrO	ZnO	Na_2O
A2	40	54	6			
A2Sr	40	49	6	5		
A2Zn	40	49	6		5	
45S5	46	27	3			24

Different bioglass particles



Osteblast growth



Methicilin-resistent *S. aureus* (MRSA)

All composites antibacterial

Summary, Conclusions and Acknowledgement

Enzymatic mineralization and addition of preformed particles impart desirable biological properties to hydrogels (promoting cell growth). The N8 Agrifood programme, UK and FWO, Belgium are thanked for financial support.