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Eco-friendly binder system development for powder injection moulding of Zirconium Silicate. A comparison with a commercial one

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Objectives

To develop a ***new*** and ***competitive*** with ***cost savings*** processing route for mineral sand

To study the influence of the composition of an ***eco-friendly*** binder along the PIM process of raw zircon powders and the comparison with a commercial water soluble binder system

Powder **I**njection **M**oulding

Mixing Powder & Polymer → *Injection moulding* → *Binder removal* → *Sintering*

net-shaping

Low cost

High productions

Small parts

Shape complexity

High performance parts

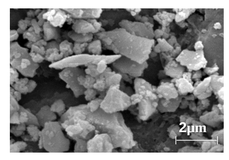
Binder requirements

- enough **viscosity** to maintain the powder in a fine dispersion
- **degradation temperatures** above moulding and mixing Tª
- good **flowability** in melted state and rigidity in the solidified
- easily **available** & **inexpensive** & **environmentally acceptable**
- **easy, fast, clean** and **defect free removal**

Materials

Powders

Powder Properties	Zircon
Morphology	Angular
Density(g·cm^{-3})	4.5
D_{50}-D_{90}	1.9-5.5 µm



60 vol.%

Binder systems

F1 Low Mw*
F2 Medium Mw*
F3 High Mw*

PEG + CAB

Water-soluble | cellulose derivative

F4 Licomont®: water soluble commercial binder

*Mw: molecular weight

Experimental procedure

Torque rheometry — 160˚C 50rpm

Capillary rheometry — 160 ˚C l/d 16:1 Corrections: *Bagley Rabinowitsch*

Compounding

F1 F3 F4 — **Shear roll**

F2 — **Twin extruder**

High pressure injection

Radiography

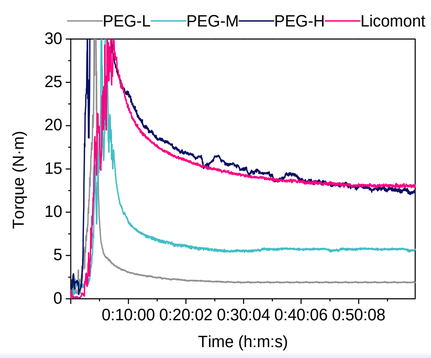
Debinding — Solvent, Thermal

Sintering — 1500˚C 3˚C /min Air

Results

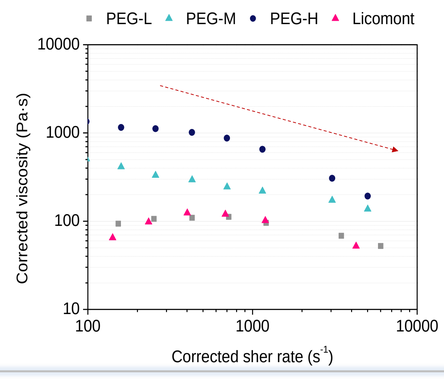
Feedstock characterisation

Torque rheometry



Steady stage → homogeneity

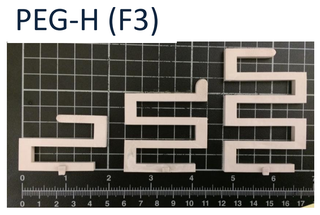
Capillary rheometry



Pseudoplastic behavior and a viscosity < 1000 Pa·s are required in PIM

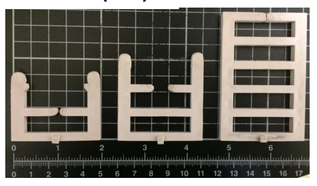
High pressure injection

PEG-H (F3)



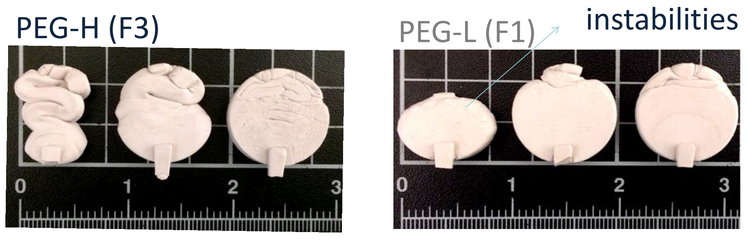
Meander is a complex shape to be injected. Complete samples were injected from all the feedstocks **F1 F2 F3 F4**

PEG-H (F3)



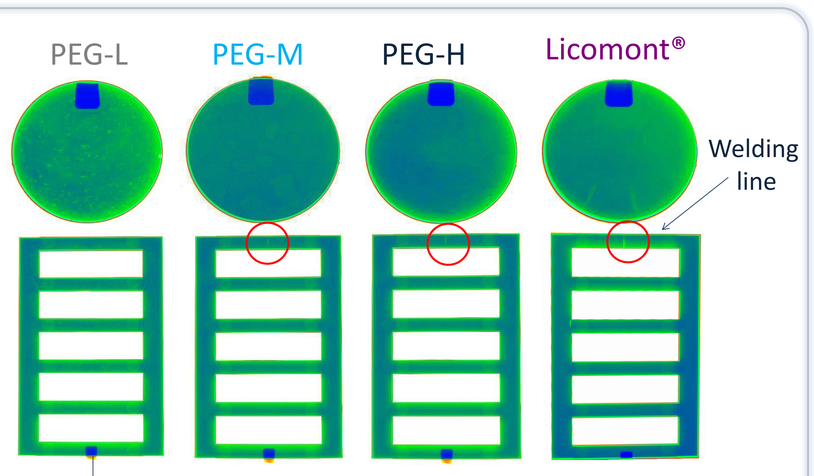
Gratings were fulfill in a symmetric way in every case, however the farthest welding line from the gate can be observed for **F2 F3 F4**

PEG-H (F3) — PEG-L (F1) — instabilities



Flow front of **F1** exhibits instabilities, it can be observed powder aglomerations. Have a corrected flow front behaviour.

radiography



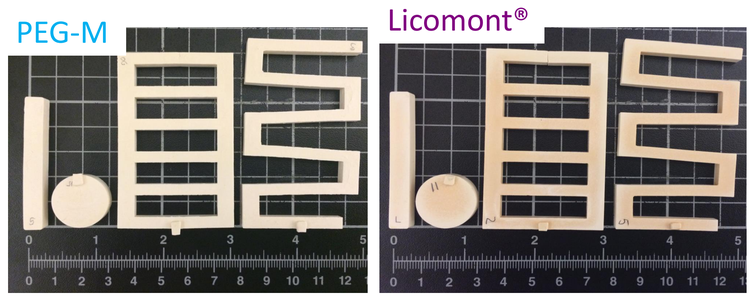
Feedstock composed of lower molecular weight of PEG is not able to achieve an homogeneous dispersion of powders

Debinding

	PEG-L	PEG-M	PEG-H	Licomont®
solvent	✓	✓	*defects*	✓
thermal	fast (4.5h) without superficial defects		*defects*	slow (50h) without superficial defects

Sintering

PEG-M — Licomont®



No superficial defects after sintering of different samples

Conclusions

- A **new** and **advantageous processing route** has been successful developed for **raw zircon powders** based on a new composition of an ***eco-friendly*** binder system
- Influence of binder composition have been studied in every stage of the **PIM** process. Best results were obtained using a PEG of medium Mw since too low Mw lead to non homogeneous dispersion and too high Mw lead to defects during solvent debinding.
- **New binder system shows short debinding cycles than commercial one**.

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