Direct Casting of Zirconia Dental Bridges and Hard Metal Tools

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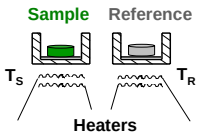
Introduction

Gel casting has been studied as an industrially viable method for rapid prototyping of hard-metal tools and direct casting of zirconia dental bridges. Direct casting in **tailor-made** molds of **complex structures** with a low amount of organics used, can be a cost effective alternative to dry-pressing for rapid prototyping of hard-metal cutting tools. Individual molding of zirconia dental bridges could also be a cost effective alternative to the current method of mechanical milling of presintered parts.

Methods

Differential Scanning Calorimetry (DSC)
Power compensated DSC was applied to study the gelation process by means of its heat of reaction.

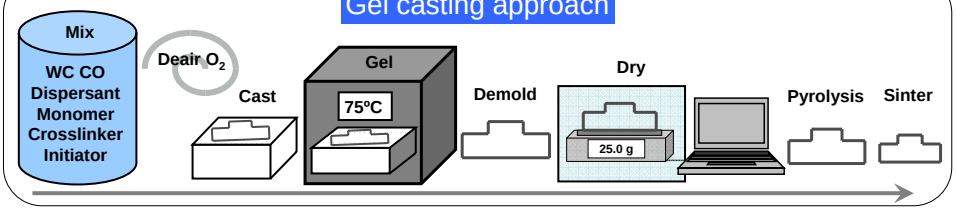


■ Isothermal measurements: To study the duration and heat evolution of the reaction.

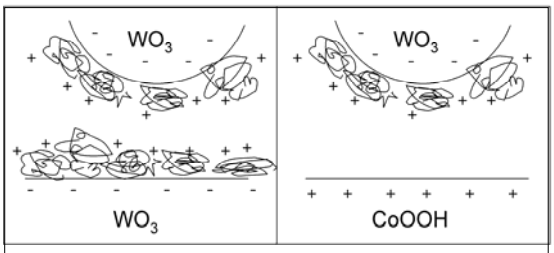
■ Thermoscan: To obtain the on-set temperature of reaction.

Important features of this method are:
❑ Sample and reference experience a controlled temperature program
❑ Zero heat-flux between sample and reference
❑ Small sample volume needed

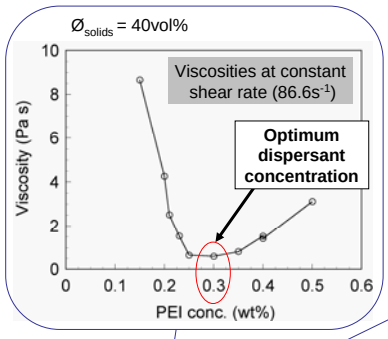
Gel casting approach



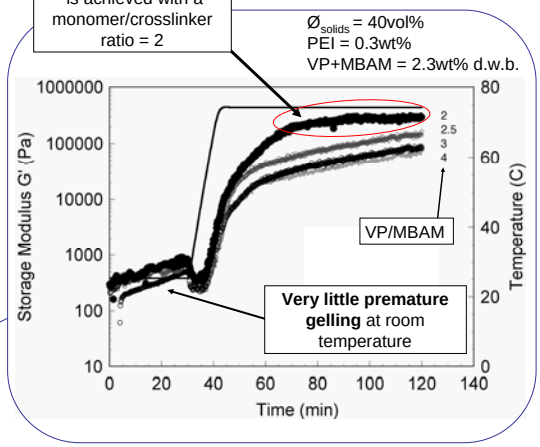
WC-Co system

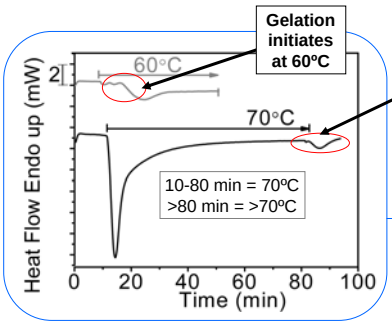


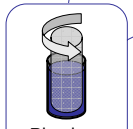
The cationic polyelectrolyte poly(ethylene imine) (PEI) is an effective **dispersant** for WC-Co powders and was used for the preparation of concentrated aqueous suspensions.

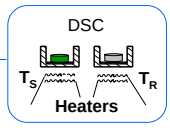


Maximum gel strength is achieved with a monomer/crosslinker ratio = 2







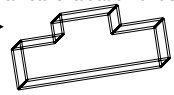


After a systematic study of numerous **gel casting systems,** the monomer **vinylpyrrolidinone** (VP) together with the crosslinker **methylenbisacrylamide** (MBAM) showed the **best potential**. This system was further optimized.

Drying in 80% relative humidity
-50% of water content in 21h

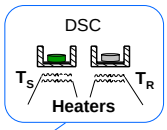
Pyrolysis in reducing atmosphere
100% binder burnout

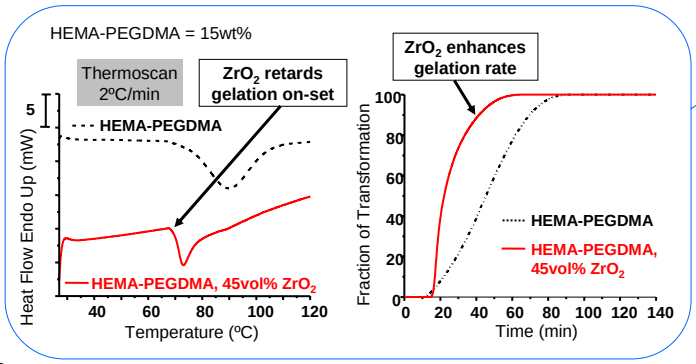
Gel cast WC-Co parts have been **successfully sintered.** Mechanical evaluation underway.

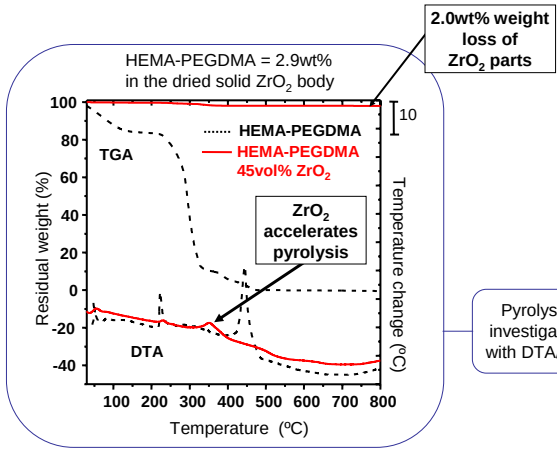


Zirconia system

A **gel-cast system for individual molding of ZrO_2 (45vol%)** with the **low-toxicity** system 2-hydroxyethyl methacrylate (HEMA) and polyethylene glycol dimethyacrylate (PEGDMA) with a monomer/crosslinker ratio of 3:1 has been investigated.







Pyrolysis investigated with DTA/TG

Summary

We have **optimized gel-casting systems** for **aqueous suspensions** of both **WC-Co** and **zirconia** powders. The suspension properties and gelation kinetics have been investigated and optimized with differential scanning calorimetry and rheology methods. The concentrated hard-metal gel-casting system shows little premature gelling. The gel, which starts to form at 60°C, has a high gel strength. Gel cast hard-metal samples were successfully sintered after controlled drying and total burnout of the organic residues.

The zirconia gel cast system behaved differently from the hard-metal system. The gelation in the WC-Co system is inhibited by the powder with dispersant, while zirconia enhances the gelation rate. The presence of zirconia powder also accelerates the pyrolysis. Future studies will involve direct casting of ceramic dental bridges and evaluation of the mechanical properties.

For further information please consult ***http://www.fos.su.se/*** *or contact* ***lennartb@inorg.su.se***

References E. Laarz et al., "Dispersing Multi-Component and Unstable Powders in Aqueous Media Using Comb-Type Anionic Polymers", J. Am. Ceram. Soc, **89** [6] 1847-1852 (2006)
B. S. Ng et al., "Using Differential Scanning Calorimetry to Follow How Gelcasting Proceeds", to be published in the Journal of the American Ceramic Society

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