Peptide “LEGO”® Hydrogel Materials

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Abstract

“LEGO”® pieces are low molecular weight peptide gelators [1]

Self-assembly process is the method of directed spontaneous organisation encoded in the building blocks.

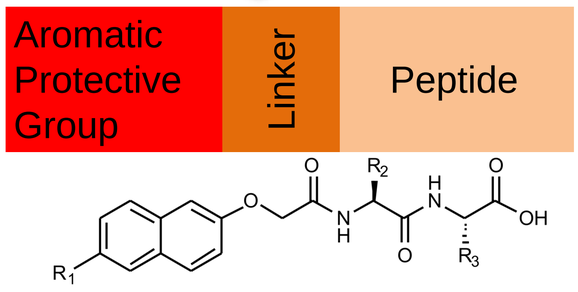
The “LEGO”® pieces get together in a particular arrangement depending on the **shape** (molecule) and the **place** (molecular environment) – The self-assembly process is key forming this materials [2]

We have developed so far a new method to access an intermediate stage of the self-assembly process [6].

At the moment we are studying the transitions that take place when a **liquid with the “LEGO”® pieces** (colloid solution) is transformed into a **hydrogel** (like gelatine).

“LEGO”® Building Blocks

[7]



	Acronym	pKa	R_1	R_2	R_3
1	2NapFF	6.0	H	Ph	Ph
2	BrNapAV	5.8	Br	CH_3	$CH(CH_3)_2$
3	BrNapFG	5.5	Br	Ph	H
4	BrNapAG	5.0	Br	CH_3	H

Fig. 1 - Structures of gelators **1** – **4** used in this study.

New Self-assembly Process

New Method 1
One-step Self-Assembly
CO_2 gas-phase pH-switch gelation

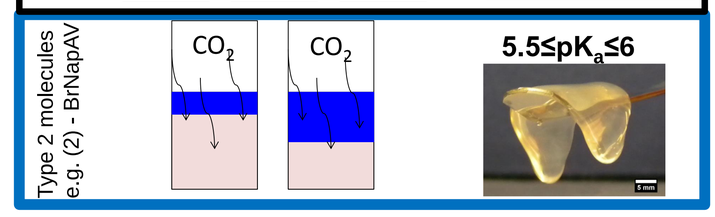
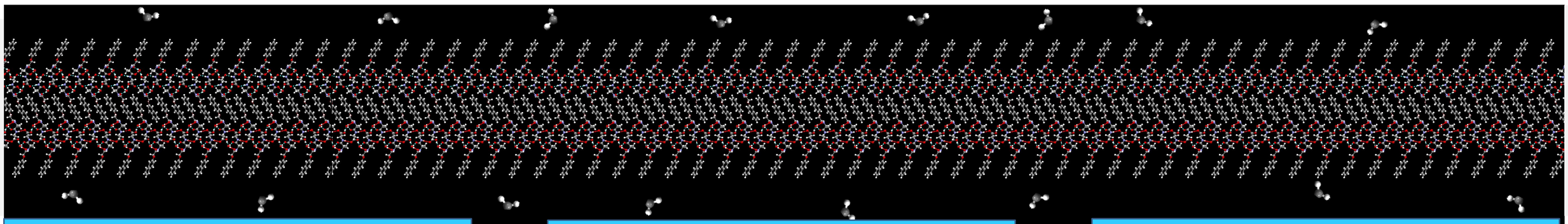
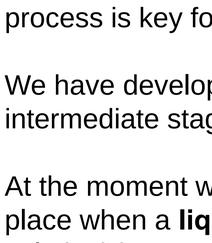


Fig. 2 – Scheme of gelation (blue) by diffusion of CO_2 (plus carbonate species) for **2NapFF, (gelator 1) – top; BrNapAV** and **BrNapFG (gelator 2 and 3**) **- bottom**.



Methods of Analysis



Rheology:
Inversion Vial Test and Rheometry

- How much viscous is it?
- How much sold-like and liquid-like is it?

pH Measurements

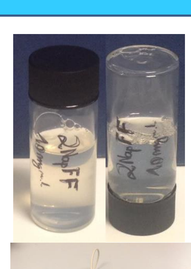
- Is it a gel at acid, neutral or basic pH? This is important for the mechanical properties of the gel.
- How does the pH change affect the gel?

Nuclear Magnetic Resonance (NMR) Spectroscopy

- NMR peak shift revels changes in molecular environment.
- This changes are different for different parts of the “LEGO”

UV-Vis (and FTIR) Spectroscopy [5]

- Can we say something about the interactions between the “LEGO”®?
- In which conditions do the “LEGO”® aggregates in a controlled way?



Pipetting Robot and Surface Tension measurements

- What amounts are required to form an aggregate before we make a gel?
- What is the critical amount required to make micellar structures?

Dynamic Light Scattering

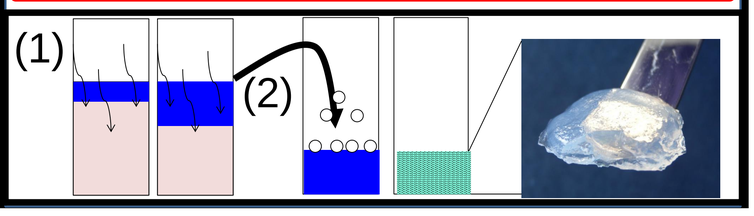
- Are there any aggregates before we form a gel?
- How large are the aggregates before they form a gel?

The hydrogel is made of entangled fibres

Advanced Materials

These materials can have up to **99,9% water** and still be stable and rigid [1,2]. Interface chemistry [3] and electrochemical methods [4] have been used to form ultra-thin films of hydrogel membranes.
This materials are formed by non-covalent bounds, which typically allows reversibility of the structures [1,2].Some of these materials are biocompatible as they are constituted of selected non-toxic degradable peptide sequences and can be degraded by body [1,2].

New Method (2)
Two-step Self-Assembly
1) pH-switch by CO_2 aqueous species.
2) Diffusion and Hydrolysis of Glucono-δ-lactone (white)



New gelation methods

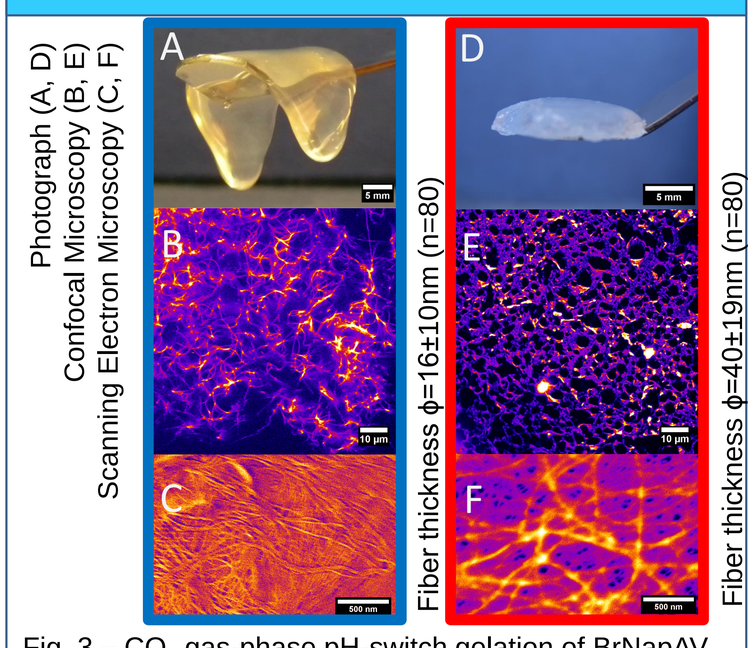


Fig. 3 – CO_2 gas-phase pH-switch gelation of BrNapAV by method 1 (A,B and C) and method 2 (D,E and F)

Conclusions

- An intermediate transition step in gelation of peptide supramolecular self-assembly materials was obtained for gelators with $5.5 \leq pK_a \leq 6$ and characterized by chemical, structural and mechanical properties [6], this intermediate self-assembled state forms a **flexible membrane** which can be **easily handled** and transferred for an application or further rigidified by a second step (method 2).
- Micellar transformation can be followed by ^{1}H-NMR and this can be associated to the fate of a potential gelator to form a gel (present work, not shown here) initiating the **first steps toward to a rational supramolecular design theory for this class of small peptide-based molecules**.

Building Hydrogels for:

- Understanding the nature of small peptide molecular Interactions;
- Biomedicine research (e.g. Tissue Engeneering, Drug Delivery or Burn Treatments)
- Cosmetics and hygienic products
- BioElectronics and biosensors

References

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