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# Gradient hydrogel based on self-filtration

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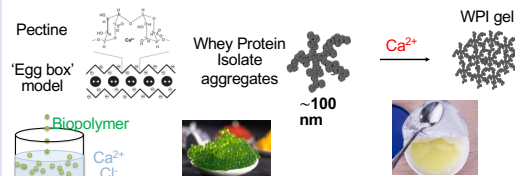
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## Introduction

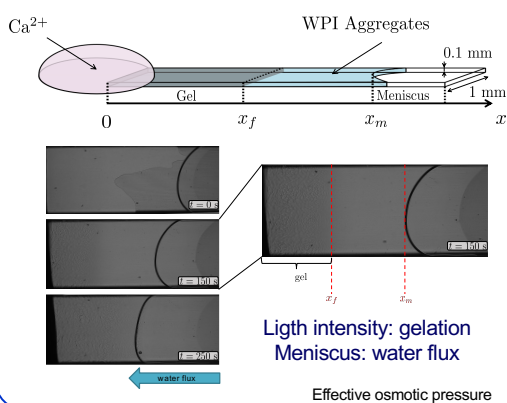
Understanding and mastering gelation of biopolymer is important for controlling the structure of gels and open the way to the design of micro-objects with a gradient of physical properties.

In this study, we investigated the gelation between a calcium solution and a suspension of biopolymers.

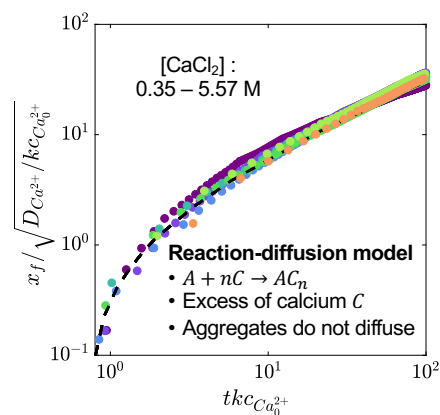
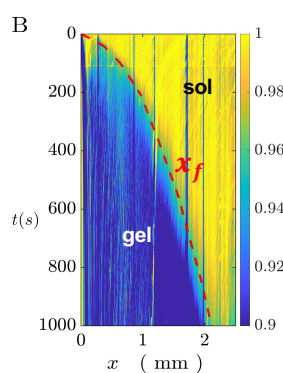
We showed that spontaneous osmotic flow through the gel controls its formation and can be used to create concentration gradients.



## The kinetics of gelation by diffusion of Ca<sup>2+</sup>

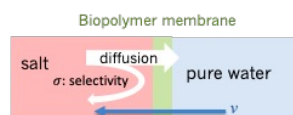


## ST map of light intensity



## Osmotic flux during gelation

### Partial selectivity: flux of solvent



$$v = \frac{\kappa}{\eta x_f} (\Delta P - \sigma \Pi)$$

$\sigma$ : reflection coef., « energy barrier »

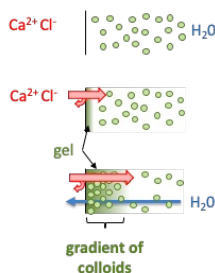
$\kappa$ : gel permeability

$\eta$ : solvent viscosity

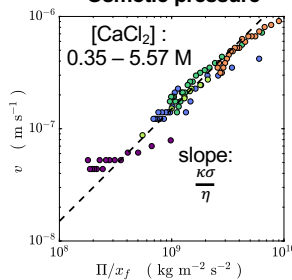
$\Pi$ : osmotic pressure

Marbach & Bocquet, Chemical Society Reviews, 2019

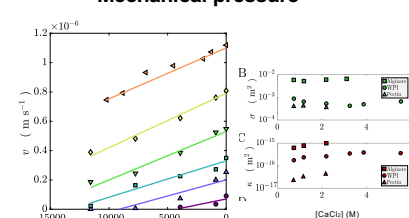
### Partial selectivity & gelation



### Flux vs. Osmotic pressure

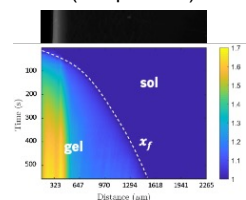


### Flux vs. Mechanical pressure

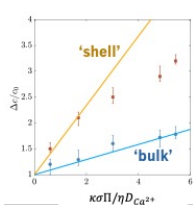


## Shell formation & core-shell micro-objects

### Gradient of concentration (fluor proteins)



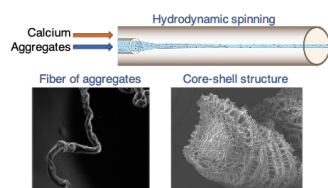
### Mass balance model



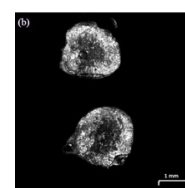
$$\frac{\Delta c}{c_0} \propto \frac{\kappa \sigma \Pi}{\eta D Ca^{2+}}$$

### Core-shell fibers of protein aggregates

Vilotte et al, ACS Applied Polymer Materials, 2022



### Capsules in pectine and cellulose



## Conclusions

- Hydrogels are partially selective to calcium ions, reflection coefficient  $\sigma \sim 10^{-5} - 10^{-3}$
- Osmotic flux occur during gelation
- Osmotic flux advects colloids and create a gradient of concentration