Friction and syneresis in agar plates

Bosi MAO (毛 博思)

Centre de Recherche Paul Pascal,
115 av. Dr. Schweitzer 33600 Pessac

Thesis Advisors: Patrick Snabre & Thibaut Divoux
Mainly composed of water (>95%!) + 1 to 4% agarose & agarpectin (polysaccharides) + small amount of amino-acid, surfactants, etc.

... are subject to Syneresis

“spontaneous or stress-induced shrinkage of the gel matrix and expulsion of solvent”

→ delayed detachment of the gel

Matsuhashi, Agar in *Food Gel*, P. Harris Ed. (1990)
“Delayed detachment” of the gel from the Petri dish

Main goals of the project:
- rationalize the delayed detachment
- monitor the shrinkage dynamics for different boundary conditions
- impact of the gel’s microstructure on the dynamics
1. Rheology

Adhesion related issue

2. Interferometry

Spatio-temporal diagram

3. Diffusing-Wave Spectroscopy (DWS)

Techniques overview
How to monitor the gel formation?

- Agar (Sigma Aldrich® or BioMérieux®)
- Agar solution (1.5% wt)
  - 100°C → 80°C
- Plate-Plate geometry (Ø 40mm)
  - Gap 500mm

Formation of an interconnected network made of double helices

San Biagio et al., Food Hydrocolloid 10, 91 (1996)
An unexpected adhesion issue!

- Protocol:
  - Temperature ramp 70°C -> 20°C
  - Isothermal regime

The gel is losing contact with the plate during its formation.

Gap increases as the temperature decreases.

The gel is losing contact with the plate during its formation.
An unexpected adhesion issue!

Protocol:
- Temperature ramp 70°C→20°C
- Isothermal regime
- Temperature compensation

Temperature compensation is not enough – no steady state regime.

\[ \gamma = 0.01\% \quad \omega = 1\text{Hz} \]
A proper protocol to monitor the gel formation

- Protocol:
  - Temperature ramp 70°C->20°C
  - Isothermal regime
  - Temperature compensation
  - Constant axial force

Outlooks: study the influence of several other parameters:
- Temperature drop, cooling rate, agar concentration, etc.
The protocol needs to be adapted to the gel...

- Protocol:
  - Temperature ramp 70°C->20°C
  - Isothermal regime
  - Temperature compensation
  - Constant axial force

The strain amplitude should be adapted to the agar concentration!

Normand et al., Biomacromolecules 1, 730 (2000)
The adhesion between the gel and the plate is a serious issue
Measuring $G'$ & $G''$ requires temperature compensation & normal force control

Take home messages & outlooks

- Our work urges to revisit some results from the literature...

Labropoulos et al., Carbohydrate Polymers 50, 407 (2002)
Norman et al., Carbohydrate Polymers 54, 83 (2003)
Grillet et al., Rheology, Vicente(Ed.), 59 (2012)
Thank you!