

NATURAL POLYMERS

Polysaccharide I

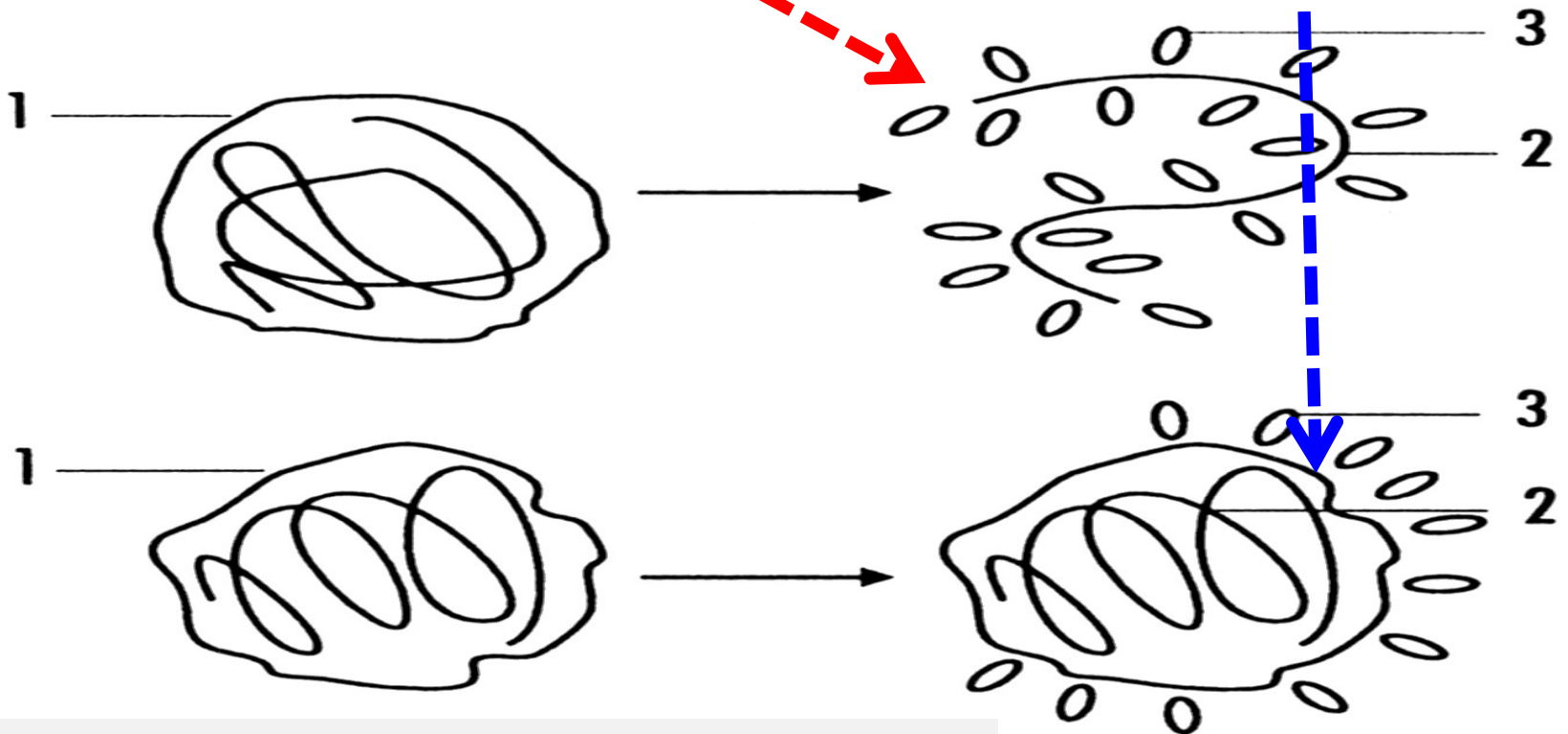
STARCH 2

Dr. Ladislav Pospíšil

Time schedule

| LECTURE | SUBJECT |
|----------------|--|
| 1 | Introduction to the subject – Structure & Terminology of nature polymers, literature |
| 2 | Derivatives of acids – natural resins, drying oils, shellac |
| 3 | Waxes |
| 4 | Plant (vegetable) gums, Polyterpene – natural rubber (extracting, processing and modification), Taraxacum_kok-saghyz |
| 5 | Polyphenol – lignin, humic acids |
| 6 | Polysaccharides I – starch |
| 7 | Polysaccharides II – cellulosis |
| 8 | Protein fibres I |
| 9 | Protein fibres II |
| 10 | Casein, whey, protein of eggs |
| 11 | Identification of natural polymers |
| | Laboratory methods of natural polymers' evaluation |

SOLUBILITY versus SWELLING



- 1. Biopolymer molecule
- 2. Polymer Chain
- 3. Water molecule or other Solvent (solvation agent)

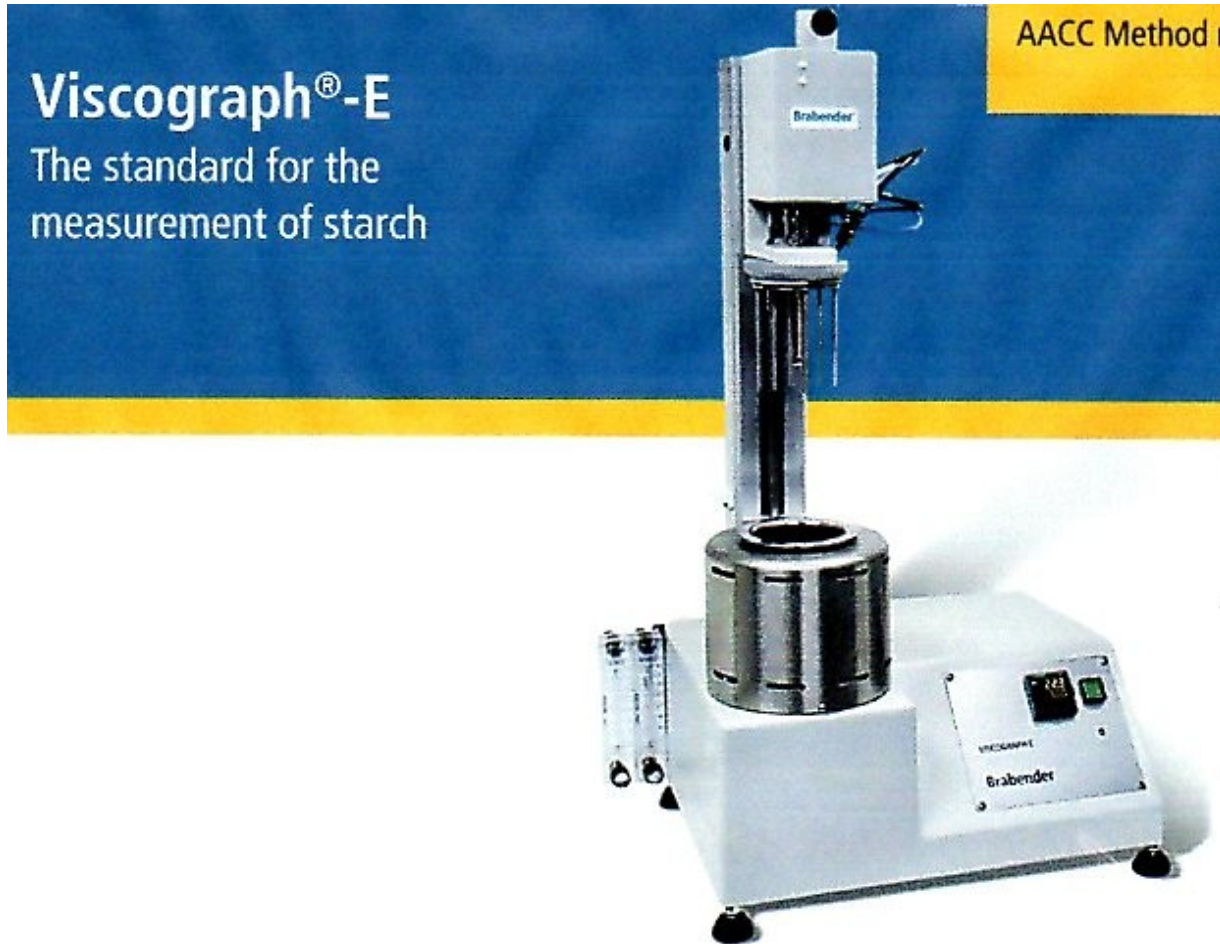
DISSOLVING OF STRACH

- **NATIV STARCH** is not soluble in the Cold Water, having Water in the in the Capillaries and Hydrogen bonds only, approx. 14 – 16 % w/w of Water
- **NATIV STARCH** after pouring to Water at the Laboratory Temperature – the only the other Pores are filled by Water
- **NATIV STARCH** in the Water at Temperature increasing to approx. 50°C – it is **SWELLING**, Hydrogen bonds are destroyed a **DISPERSION OF SWOLLEN** (hydrated) Particles in Water
- **THE FULL HYDRATATION** occurs (maximal for the particular Starch) after taking another Water and a Gel are arising (**AMYLOPECTIN**) or High Viscosity Solution (**AMYLOSE**)
- **THE RESULTING STATE IS CALLED *GELATION***
STARCH

Behaviour of Starch in Water

- **Laboratory Temperature:** the Reversible filling of the **Capillaries** in the Starch Particle only
- **Temperature Increasing:** the steady Hydratation and Destruction of the **Hydrogen bonds**, AMYLOSE DISOLVING, the only Swelling of the AMYLOPECTIN
- **Temperature Increasing & Mixing:** **Hydrogen bonds are destroyed and so called „ *GELATION STARCH (GELLING) POINT (Peptisation)*“**
- ***GELATION STARCH (GELLING) POINT* is characteristic for each type native or modified Starch**

STARCH GELLING Curves of Starch in Water



- Suited for starch and flour
- Usage for acid and lye
- Small sample size (5 - 15 g)
- Short measuring times
- Speed (0 - 300 min⁻¹)
- Temperature measurement within the sample
- Heating / cooling rates of up to 10°C / min
- No follow-up costs
- Evaluation in **BU**, mPas, cP or cmg

Modified ROTATION VISCOSIMETER

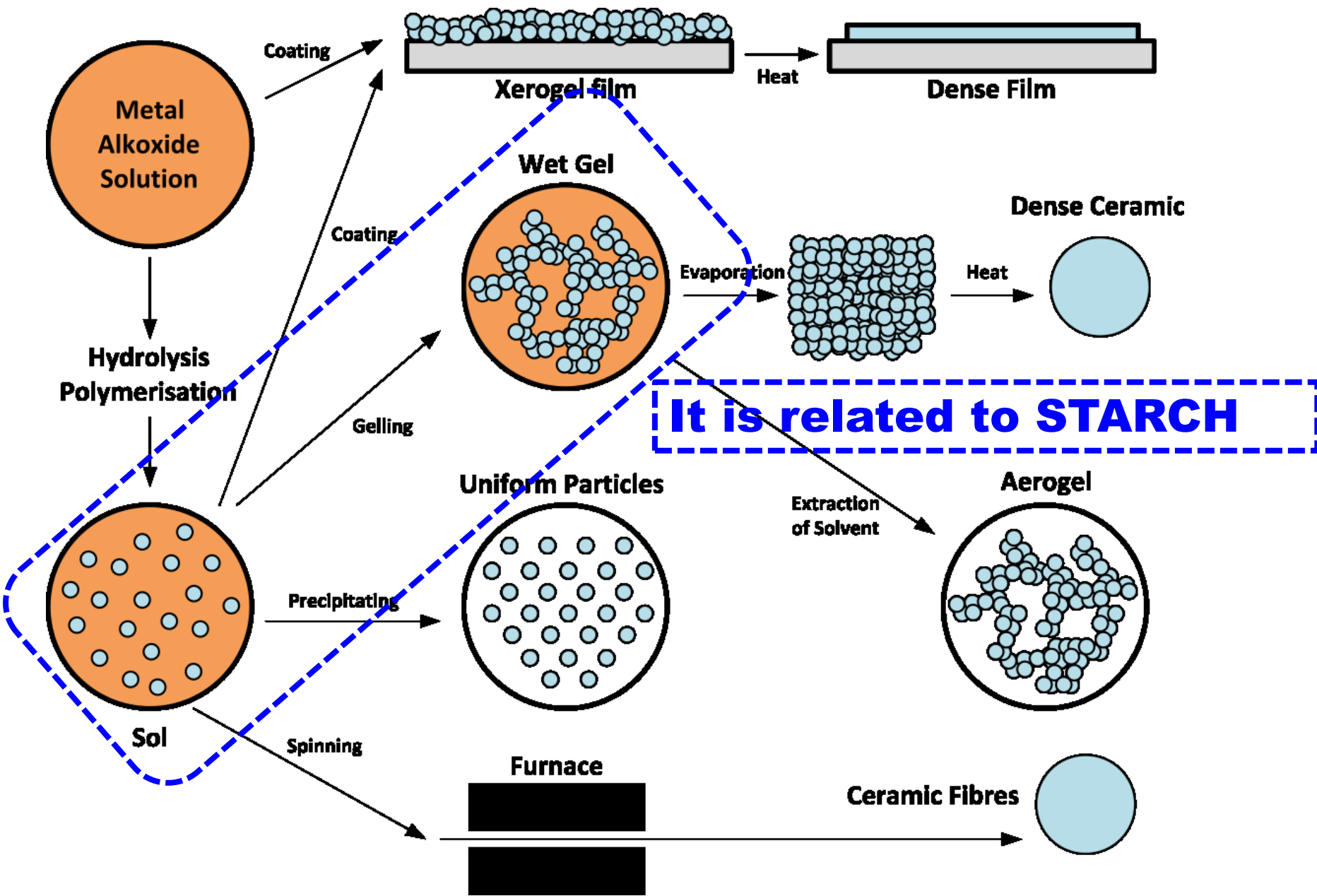
ROTATION VISCOSIMETER

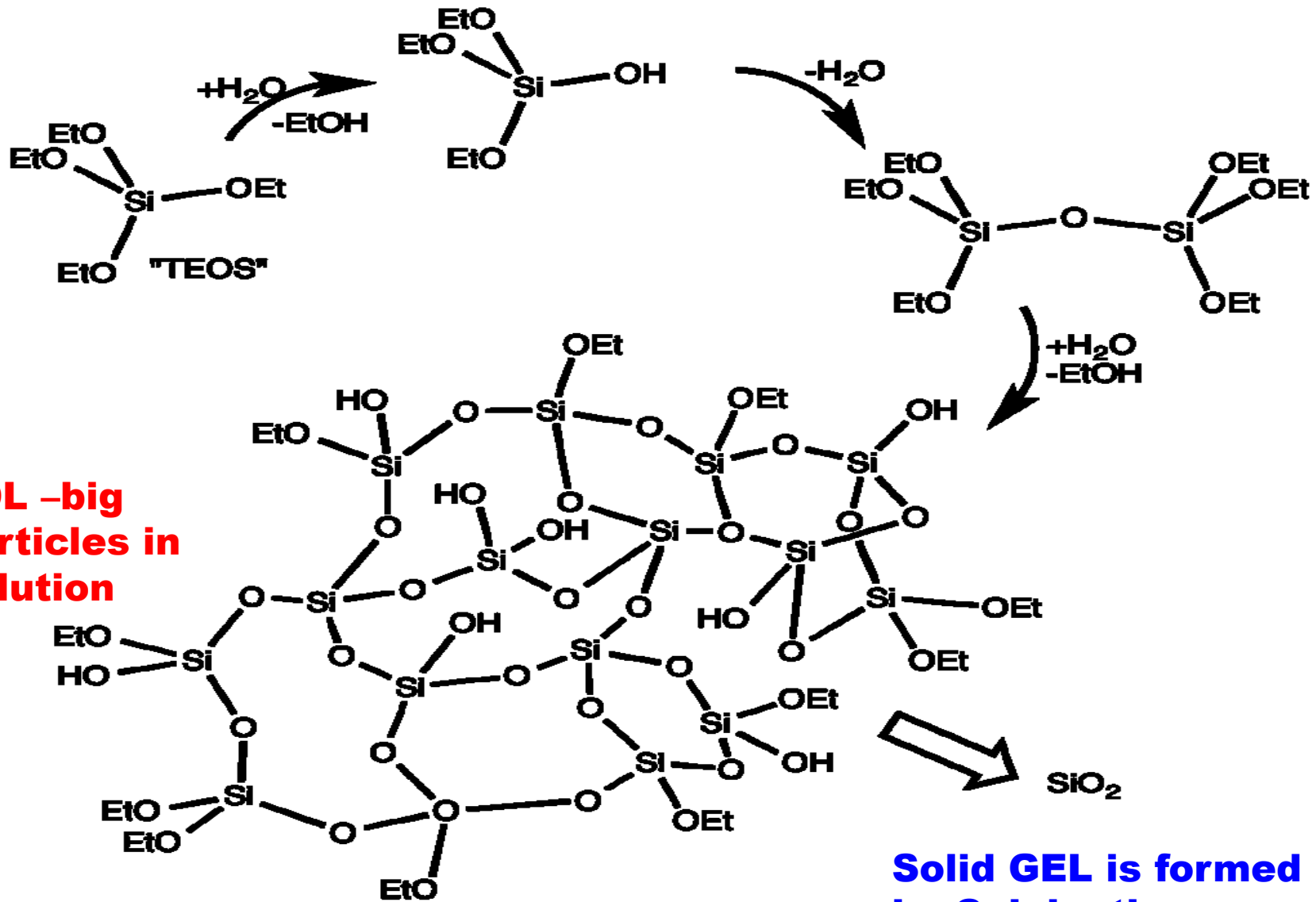


**Modified ROTATION
VISCOSIMETER**



**Standard ROTATION
VISCOSIMETER**



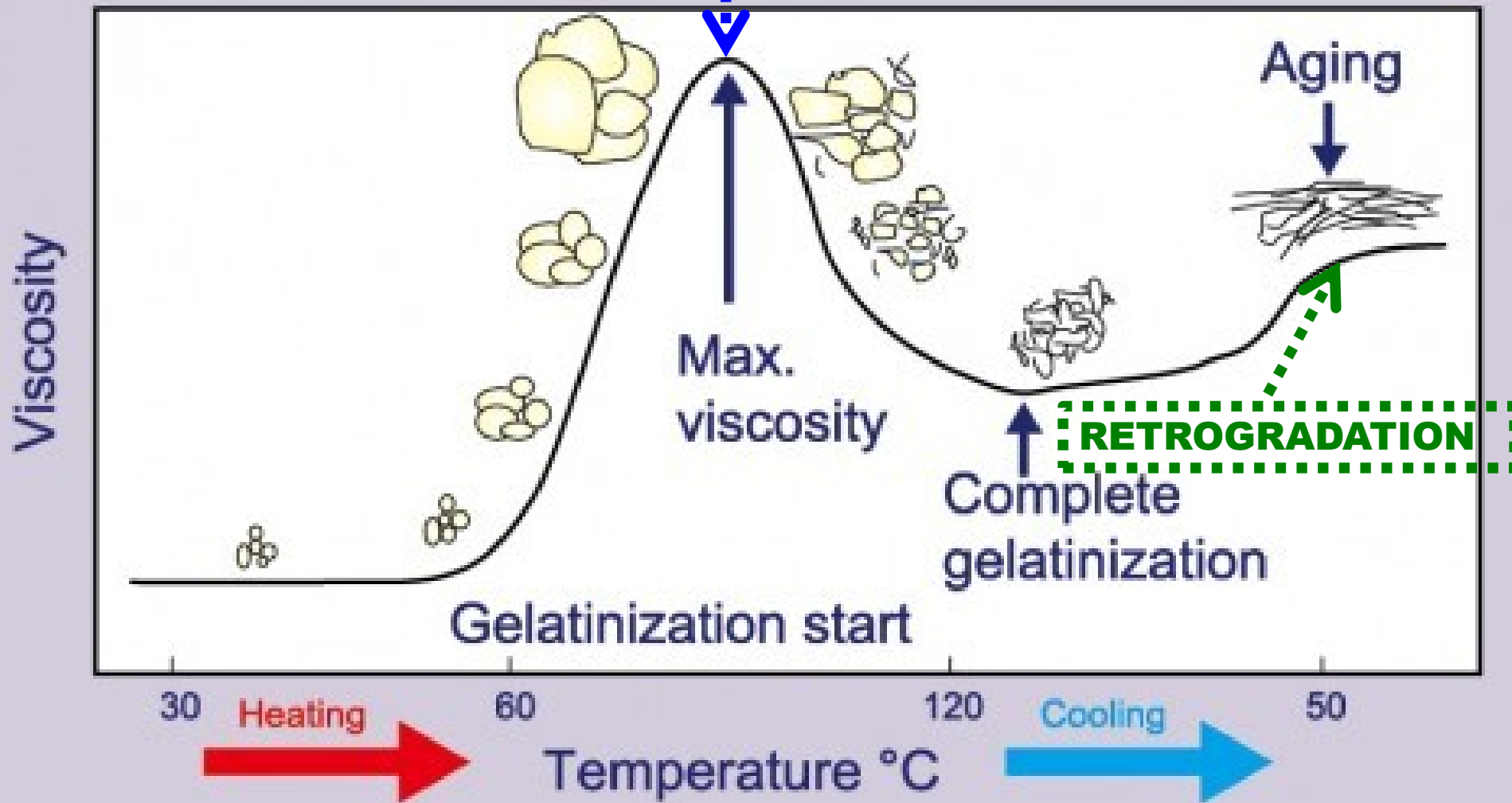


**SOL -big
Particles in
Solution**

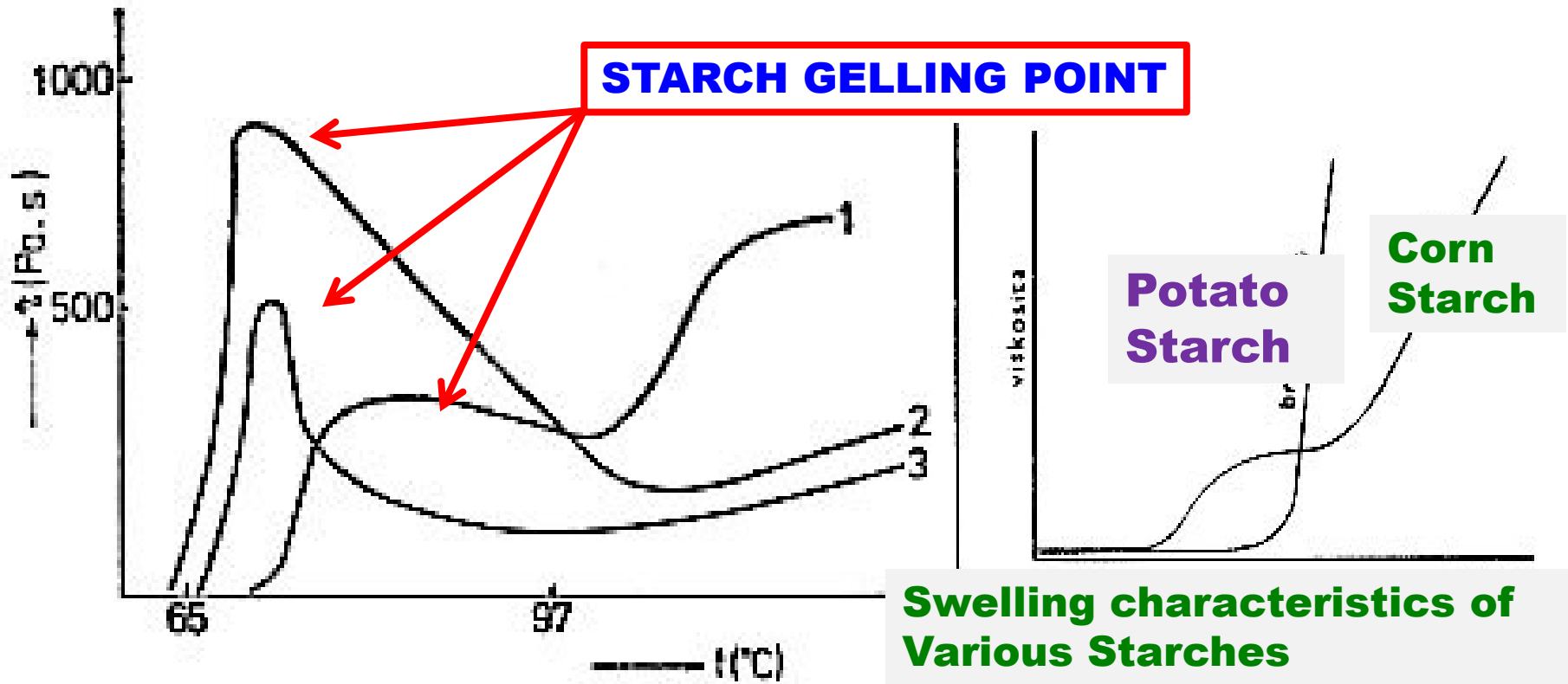
**Solid GEL is formed
by Calcination**

STARCH GELLING Curves of Starch in Water – in GENERAL

STARCH GELLING POINT



STARCH GELLING Curves of various sorts of Starch in Water 2

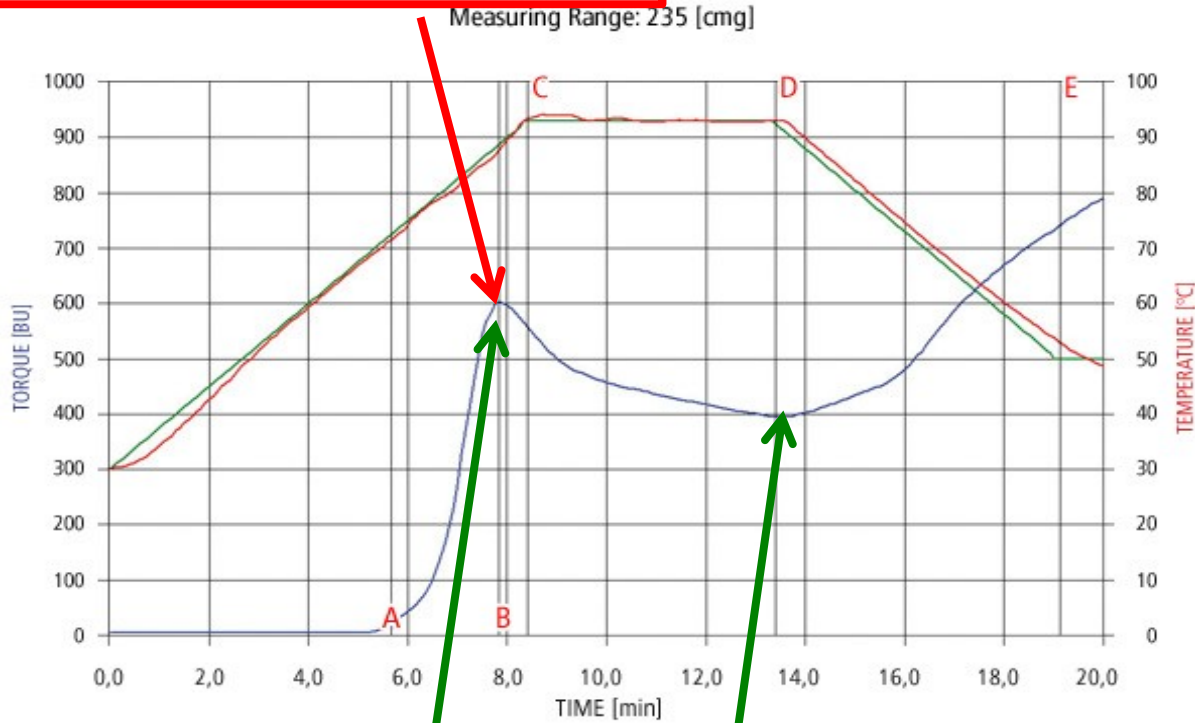


Viscosity curves of native Starches:

1) Wheat Starch, 2) Potato Starch, 3) Corn Starch

STARCH GELLING Curves of Starch in Water¹

STARCH GELLING POINT



- Suited for starch and flour
- Usage for acid and lye
- Small sample size (5 - 15 g)
- Short measuring times
- Speed (0 - 300 min⁻¹)
- Temperature measurement within the sample
- Heating / cooling rates of up to 10°C / min
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- Evaluation in BU, mPas, cP or cmg

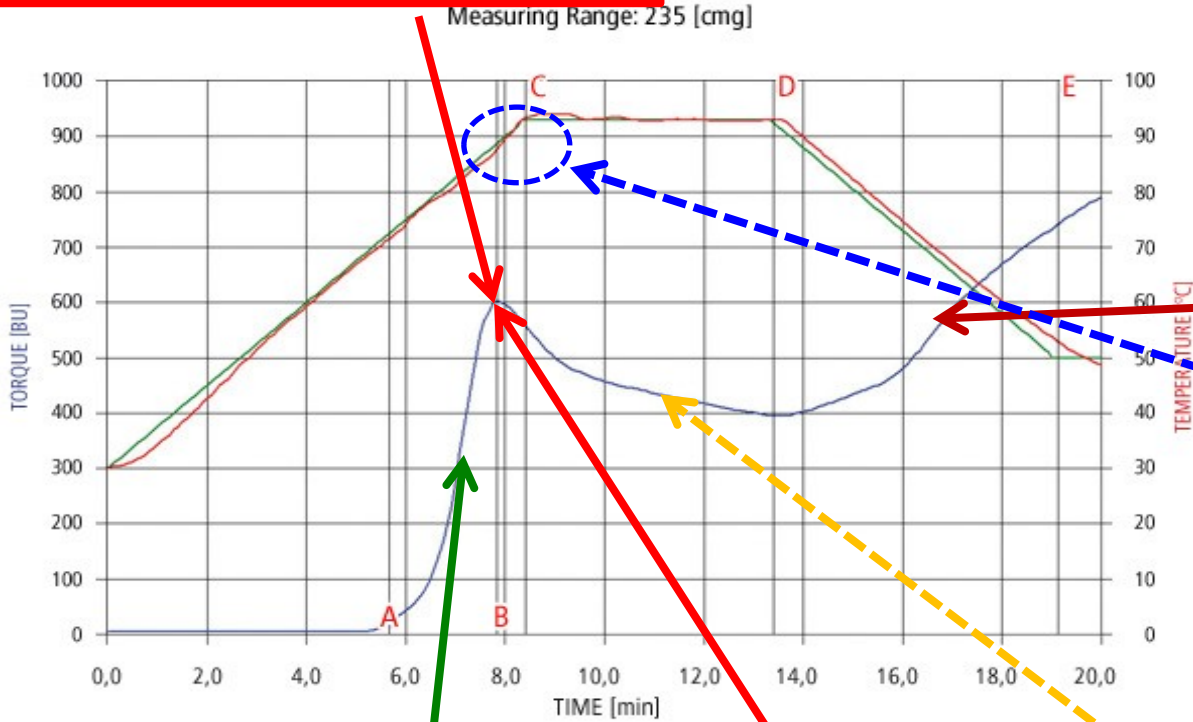
Take notice of the **COURSE**
TEMPERATURE MEASUREMENT
and Points its Changes!

Brabender is the German manufacturer of such Devices

BU = Brabender Unit

STARCH GELLING Curves of Starch in Water 3

STARCH GELLING POINT



RETROGRADATION =
viscosity Increasing
with Temperature
Decreasing > GEL
FORMING

*Coast along (INCREASES)
after Temperature
switching to Constant
Temperature*

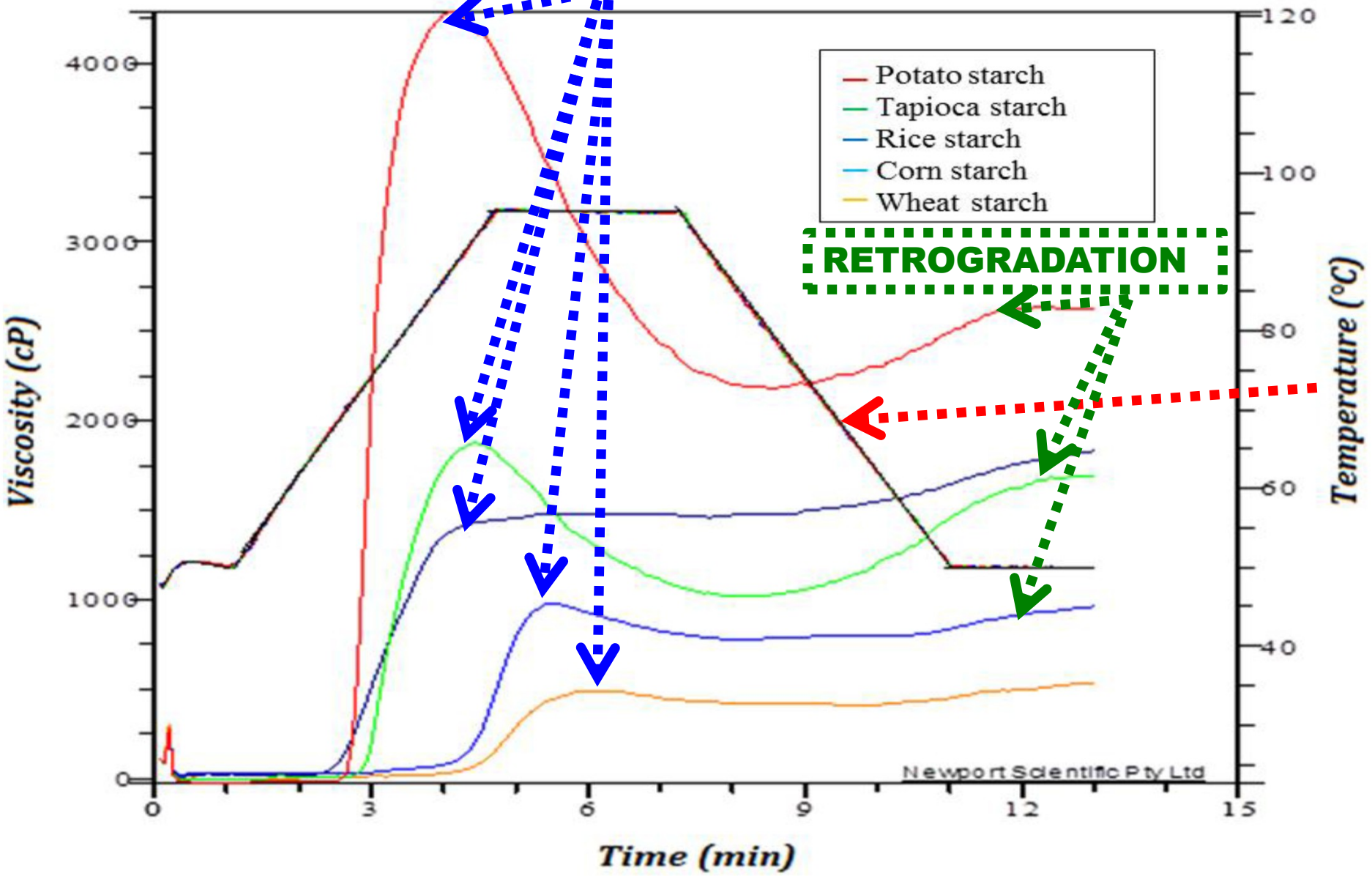
Releasing of the Smaller
Hydrated Structures > SOL

Gradual dissolving of
the Shorter chains and
their Diffusion to Water
> VISCOSITY
INCREASING

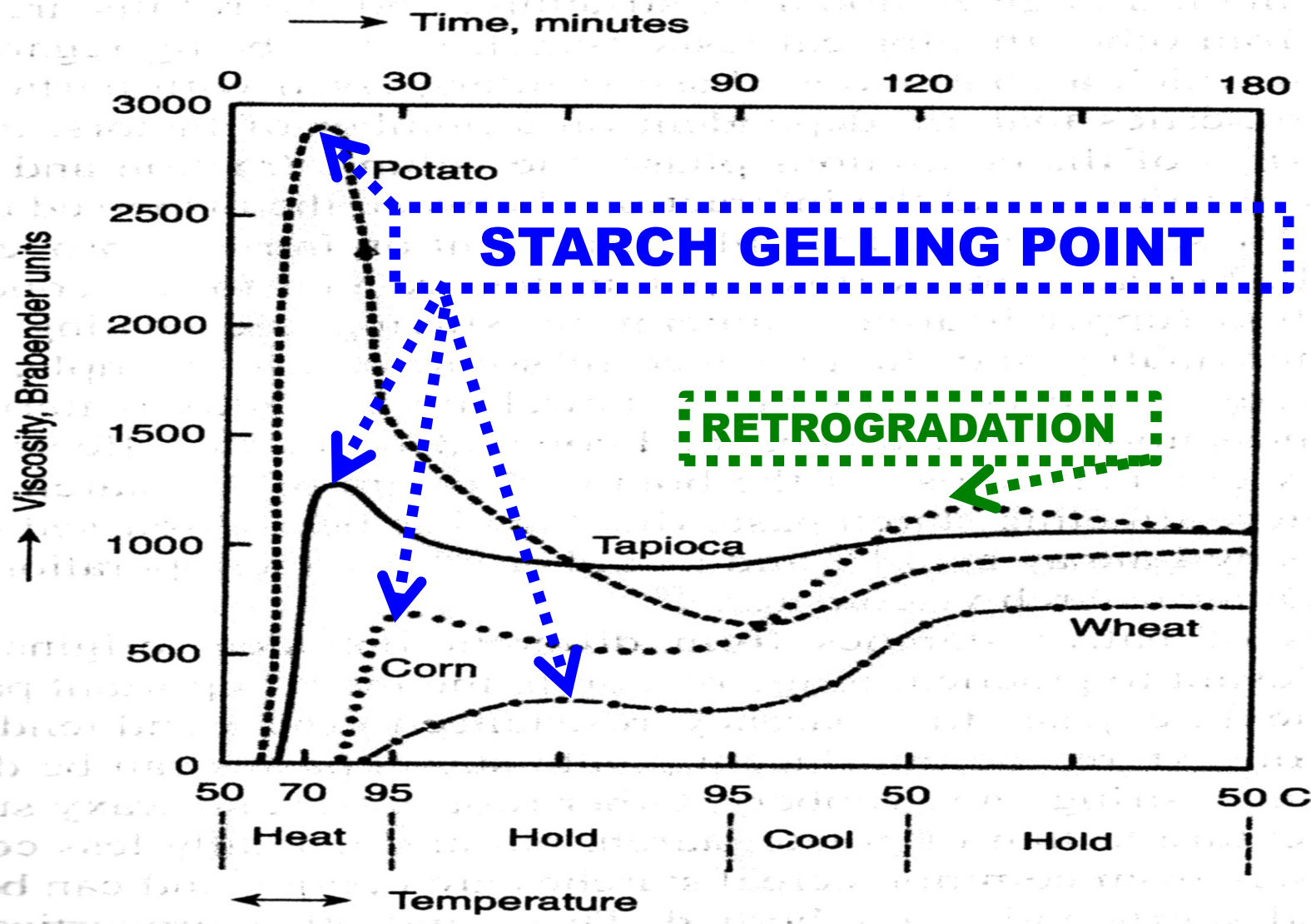
Hydrogen bonds
Destruction between
Starch chains and
hydration of the all
Starch particle, Three-
dimensional network >
GEL

STARCH GELLING Curves of Starch in Water 4

STARCH GELLING POINT



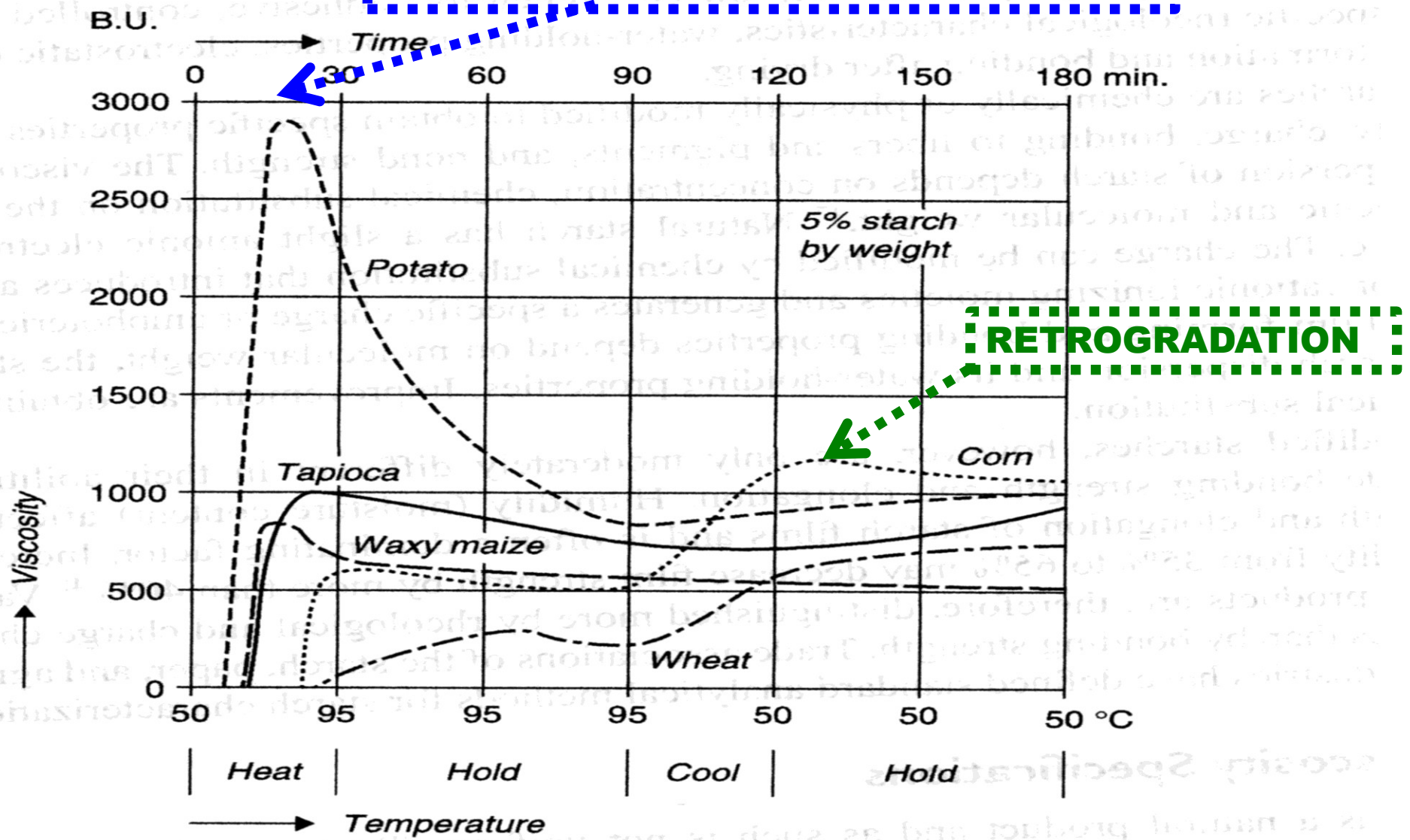
STARCH GELLING Curves of Starch in Water 5



Typical Brabender viscosity curves of 8% granular suspensions of common starches.¹

STARCH GELLING Curves of Starch in Water 6

STARCH GELLING POINT



Brabender ViscoAmylograph traces for commercial starches (5% starch by weight in water).

STARCH GELLING Curves of Starch in Water 7

STARCH GELLING POINT

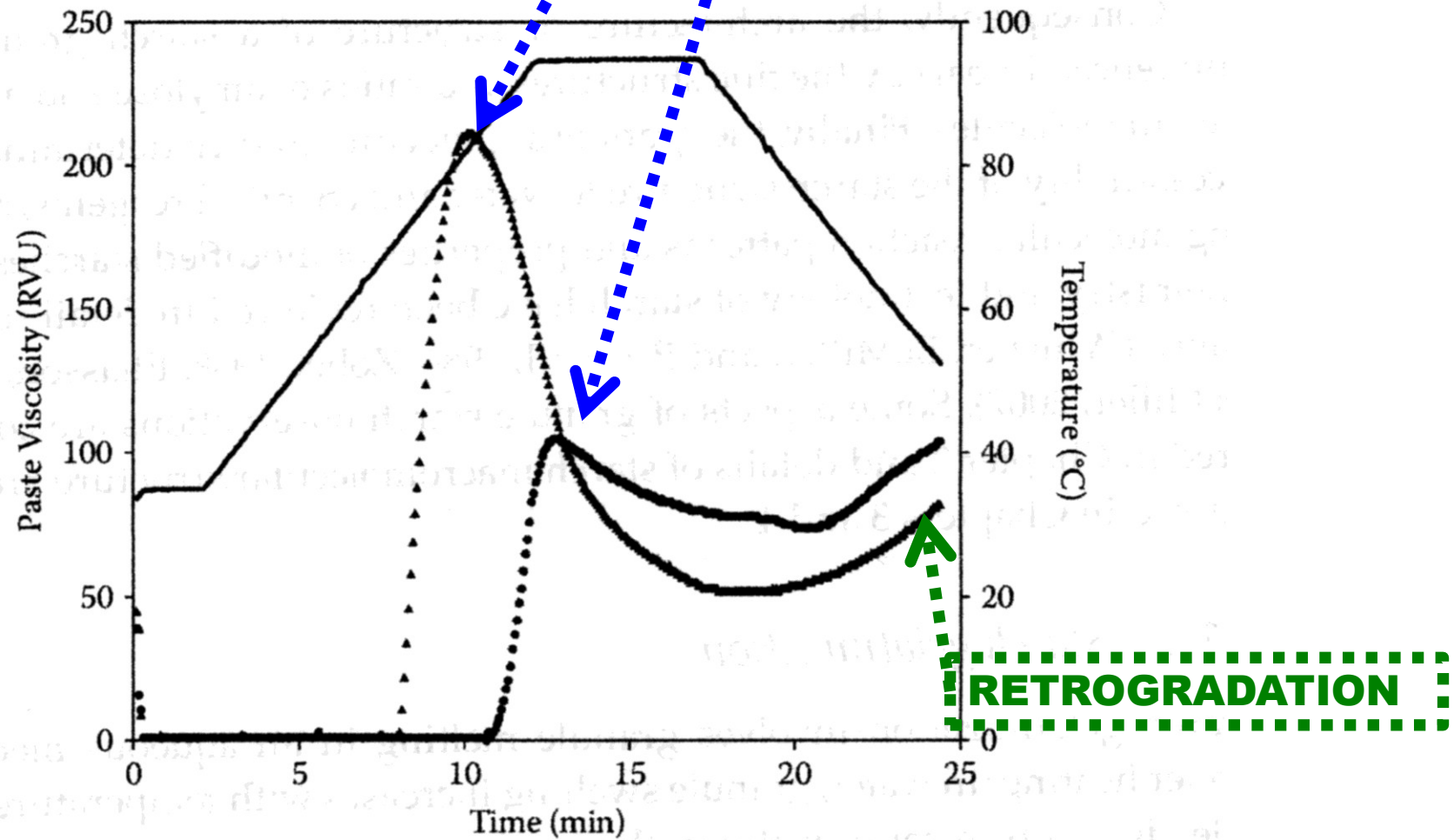
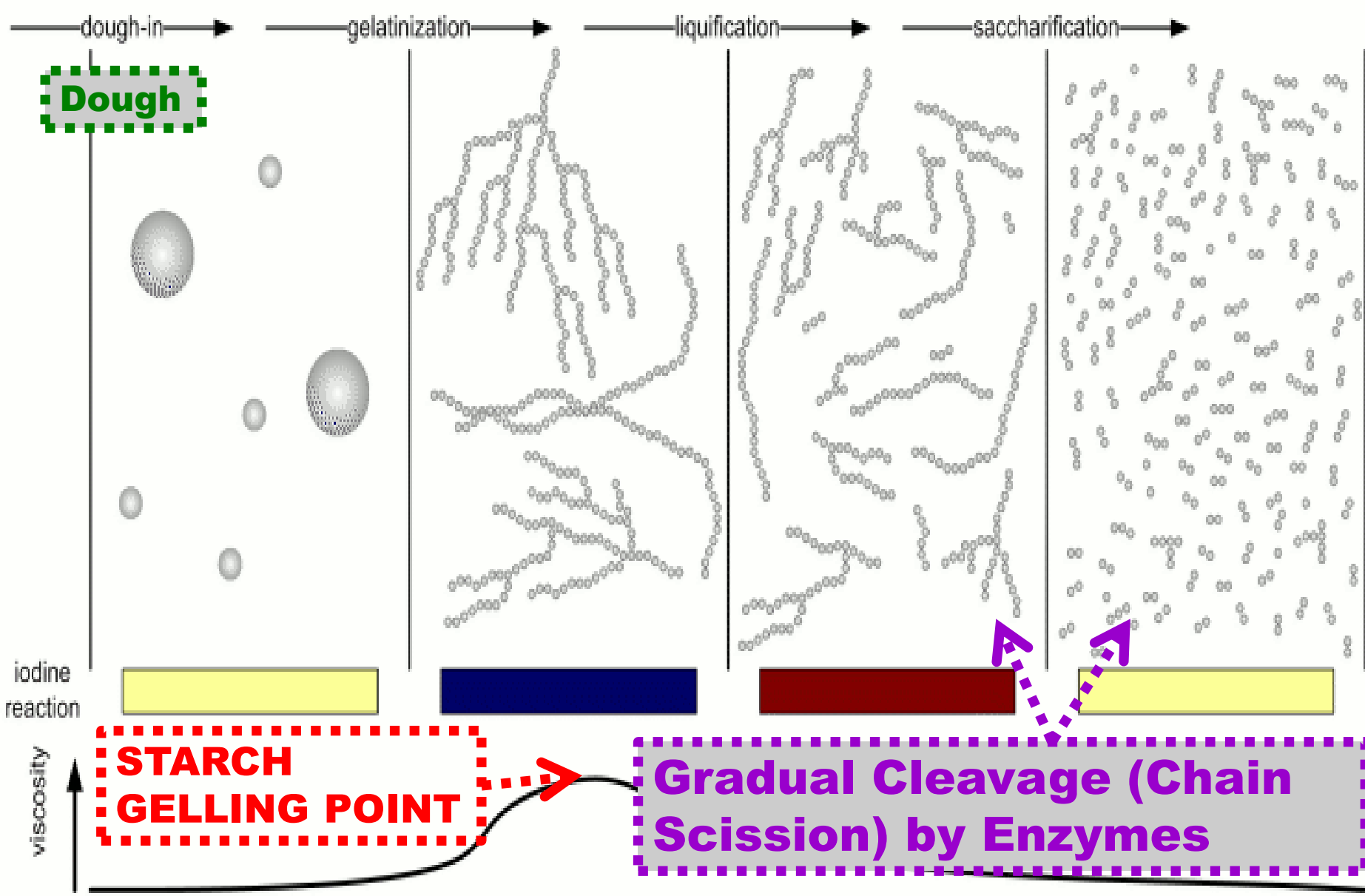
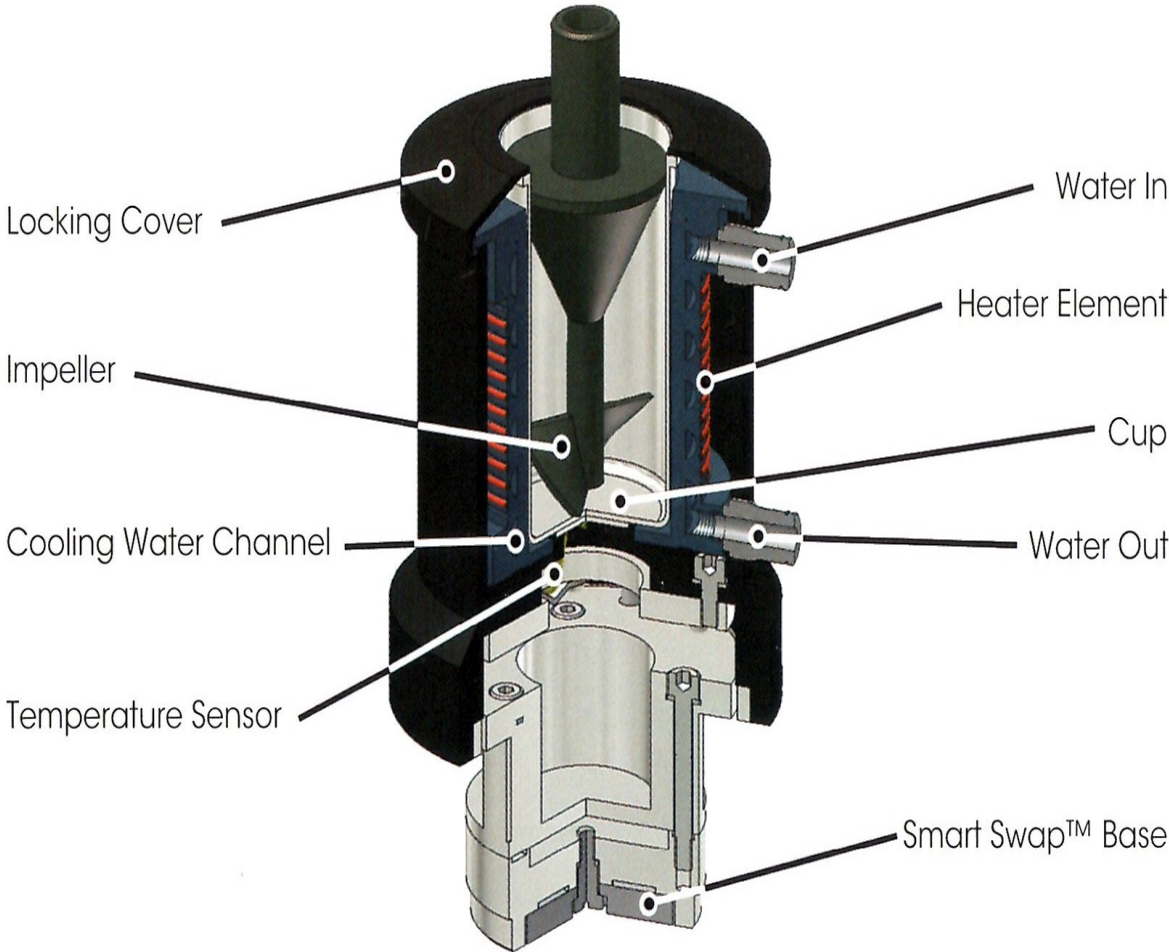


Figure 1.2 Pasting profiles of cassava (▲) and corn (●) starches, under temperature (-) changes.

STARCH GELLING Curves of Starch in Water 8

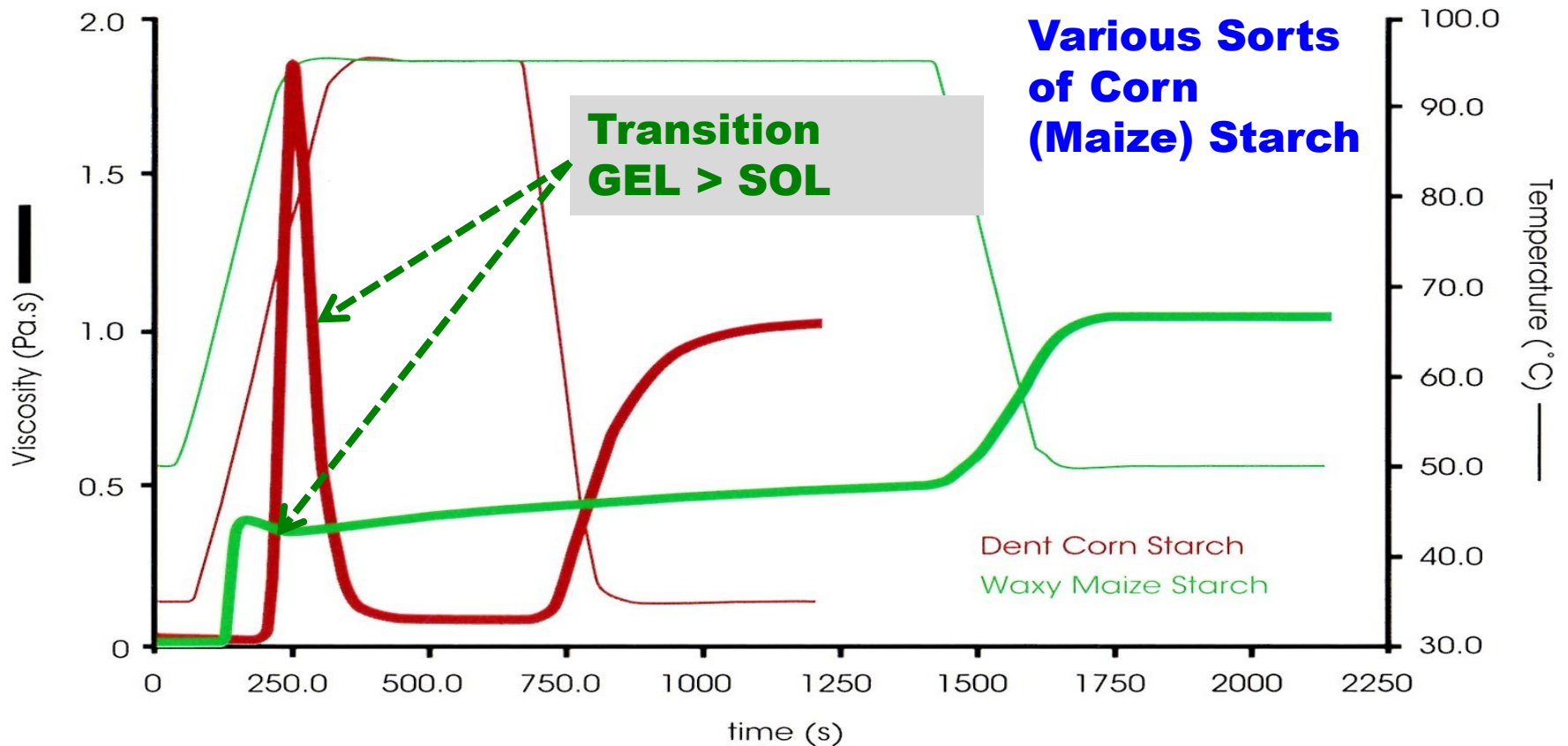


Another type of the Viscosimeter for Measurement of the STARCH GELLING POINT 1



Another type of the Viscosimeter for Measurement of the STARCH GELLING POINT 2

Two Scans each of Dent Corn and Waxy Maize Starch



VISCOSITY IS GIVEN IN THE SI UNITS!

STARCH GELLING POINT - various Starches

| Starch | GELLING POINT Temperature (°C) | | |
|----------------------|--------------------------------|-----------------------------------|--------|
| | Starting | Final | Middle |
| Potato | 59 | 60 | 63,5 |
| Corn (Maize) | 62 | 72 | 67 |
| Wheat | 58 | 64 | 60 |
| Rye | 57 | 70 | 61 |
| Rice | 68 | 78 | 74,5 |
| Pea | 55 | 70 | 65 |
| Waxy Corn (Maize) | 63 | 72 | 65 |
| Amylose Corn (Maize) | 67 | Full Gelling in the boiling Water | 80 |

STARCH GELLING POINT - various Additives to Water

| Corn (Maize) Starch | GELLING POINT Temperature (°C) | | |
|----------------------------|---------------------------------------|--------------|---------------|
| Additives | Starting | Final | Middle |
| 5 % w/w Saccharose | 60,5 | 72,5 | 67 |
| 10 % w/w Saccharose | 60 | 74 | 67 |
| 20 % w/w Saccharose | 65,5 | 78 | 74 |
| 40 % w/w Saccharose | 72 | 85 | 79,5 |
| 60 % w/w Saccharose | 84 | 96,5 | 90,5 |
| 0,2 % w/w NaOH | 55,5 | 69,5 | 64 |
| 0,3 % w/w NaOH | 49 | 65 | 59 |

STARCH GELLING POINT - various Additives to Water

| Corn (Maize) Starch | GELLING POINT Temperature (°C) | | |
|--|---------------------------------------|--------------|---------------|
| Additives | Starting | Final | Middle |
| 5 % w/w Na₂CO₃ | 64 | 72 | 70 |
| 10 % w/w Na₂CO₃ | 67 | 76 | 72 |
| 20 % w/w Na₂CO₃ | 77,5 | 87 | 82 |
| 30 % w/w Na₂CO₃ | 92 | 103 | 98 |
| 1,5 % w/w NaCl | 67,5 | 77 | 72 |
| 3 % w/w NaCl | 69,5 | 78,5 | 74 |
| 6 % w/w NaCl | 75 | 82,5 | 79,5 |

STARCH GEL BEHAVIUR in Water

- Decreasing Temperature: gradual Regeneration of the Hydrogen Bonds, mainly at AMYLOSE, the Starch having high Content of the AMYLOPECTIN (Branched macromolecule) has lower Tendency to **RETROGRADATION**
- They precipitate from the Solution as the Flakes at low Concentration, up to approx. 3 % w/w
- The Gel is formed at high Concentrations, having High Viscosity
- This Process is called **RETROGRADATION** and it possible to retard it by Addition of e.g. Glucose, Fats or Inorganic Salts (e.g. NaNO_3)