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## Flow process and heating conditions modulate the size and properties of whey protein aggregates

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# 32nd EFFoST International Conference

6-8 November 2018 **Nantes, France**

Developing innovative food structures & functionalities through process  
& reformulation to satisfy consumer needs & expectations



## Flow process and heating conditions modulate the size and properties of whey protein aggregates

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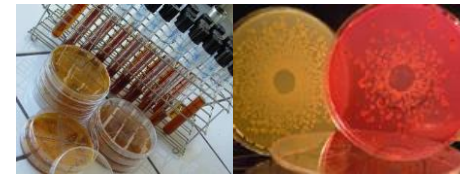


**A multidisciplinary and multiscale approach,  
reinforced by two high-calibre facilities:**

Dairy Platform



Biological Resource Centre



- ❑ **Structuration / destructuration mechanisms of food matrix:**

*from structural characterisation to digestion*

- ❑ **Dairy processing and cheese making:**  
*toward sustainable dairy systems*

- ❑ **Microbial interaction:**  
*food matrix and host cell*



# CONTEXT

## Consumer expectation

- Good organoleptic quality
- More natural and healthy products



2014-2019  
Joelle LEONIL

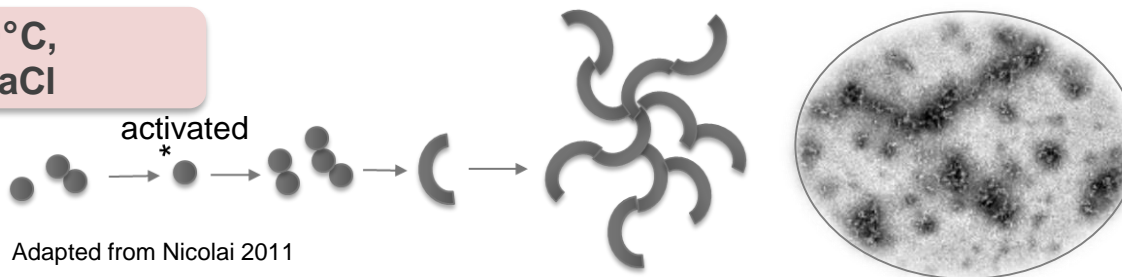
## Industrial expectation

- Target regular products properties by using additives
- Use less additives as possible (Clean label)
- **Add value to milk protein (technofunctional interest)**



## Fractal aggregates : Whey protein aggregates

WPI, 80°C,  
pH 7, NaCl



Adapted from Nicolai 2011

- Repeated pattern
- Soluble
- Low density
- Fractal dimension (Df)  $\approx$  2.2

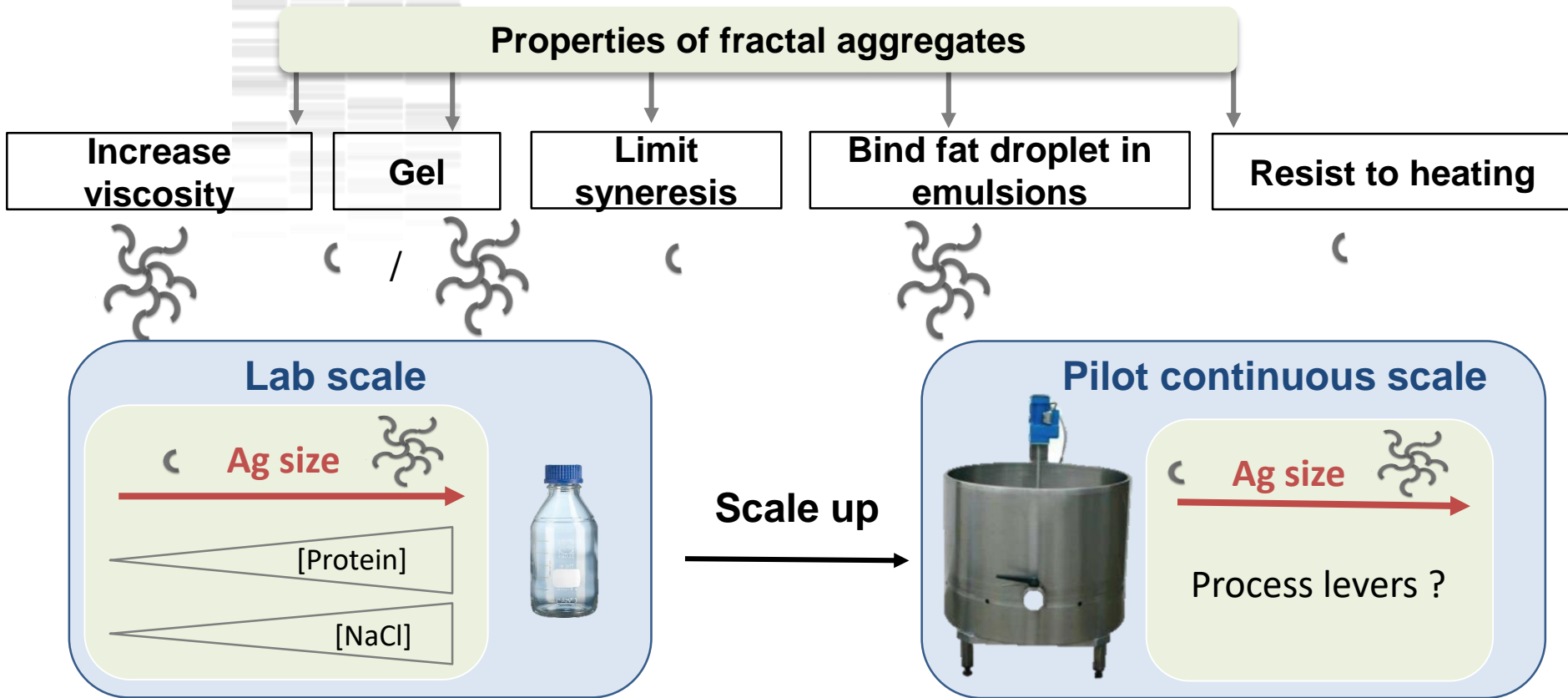
Background & RQ

Strategy

Results / discussion

Conclusion

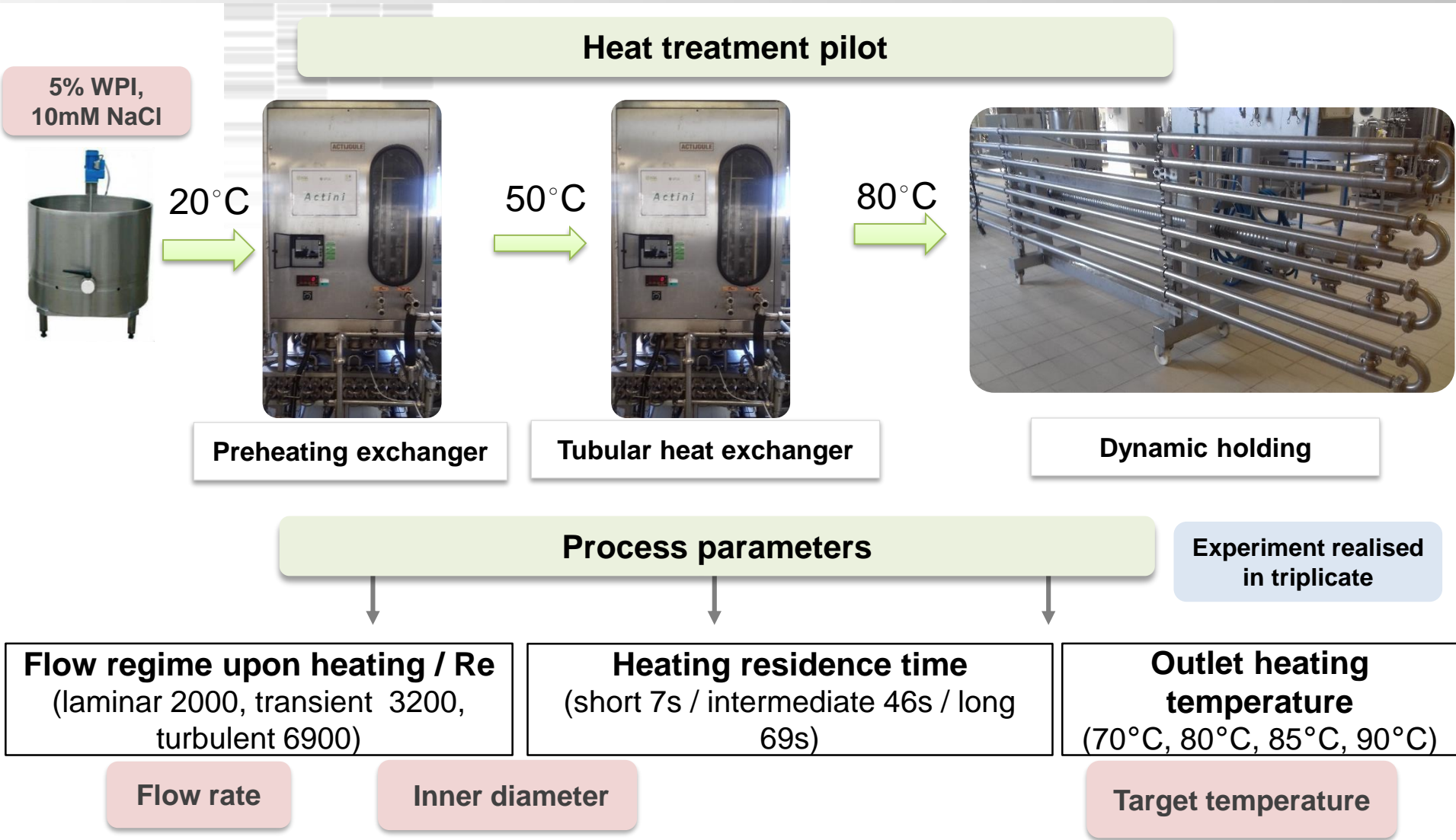
# PROPERTIES OF FRACTAL AGGREGATES AND RESEARCH QUESTION



## Research question

At pilot scale, does the process parameters influence the **characteristics of fractal aggregates** obtained, in relation to different transport phenomena (heat, momentum, mass)?

# PROCESS LEVERS INVESTIGATED



# SIZE AND SHAPE CHARACTERIZATION

PROCESS LEVRS

WPI powder

Fractal aggregates with different size

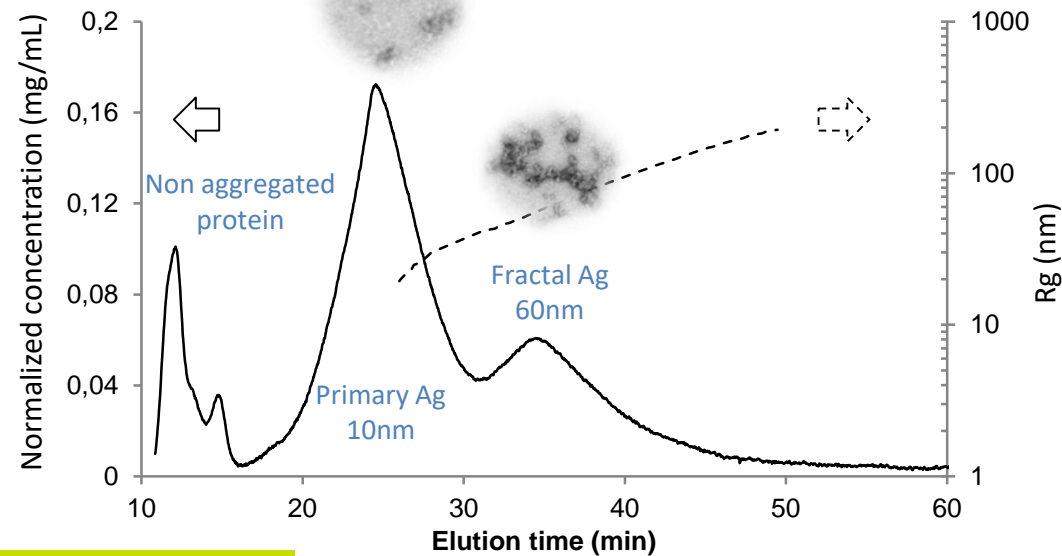
Size characterization

Asymmetrical Flow Field-Flow Fractionation (A4F)

Shape characterization

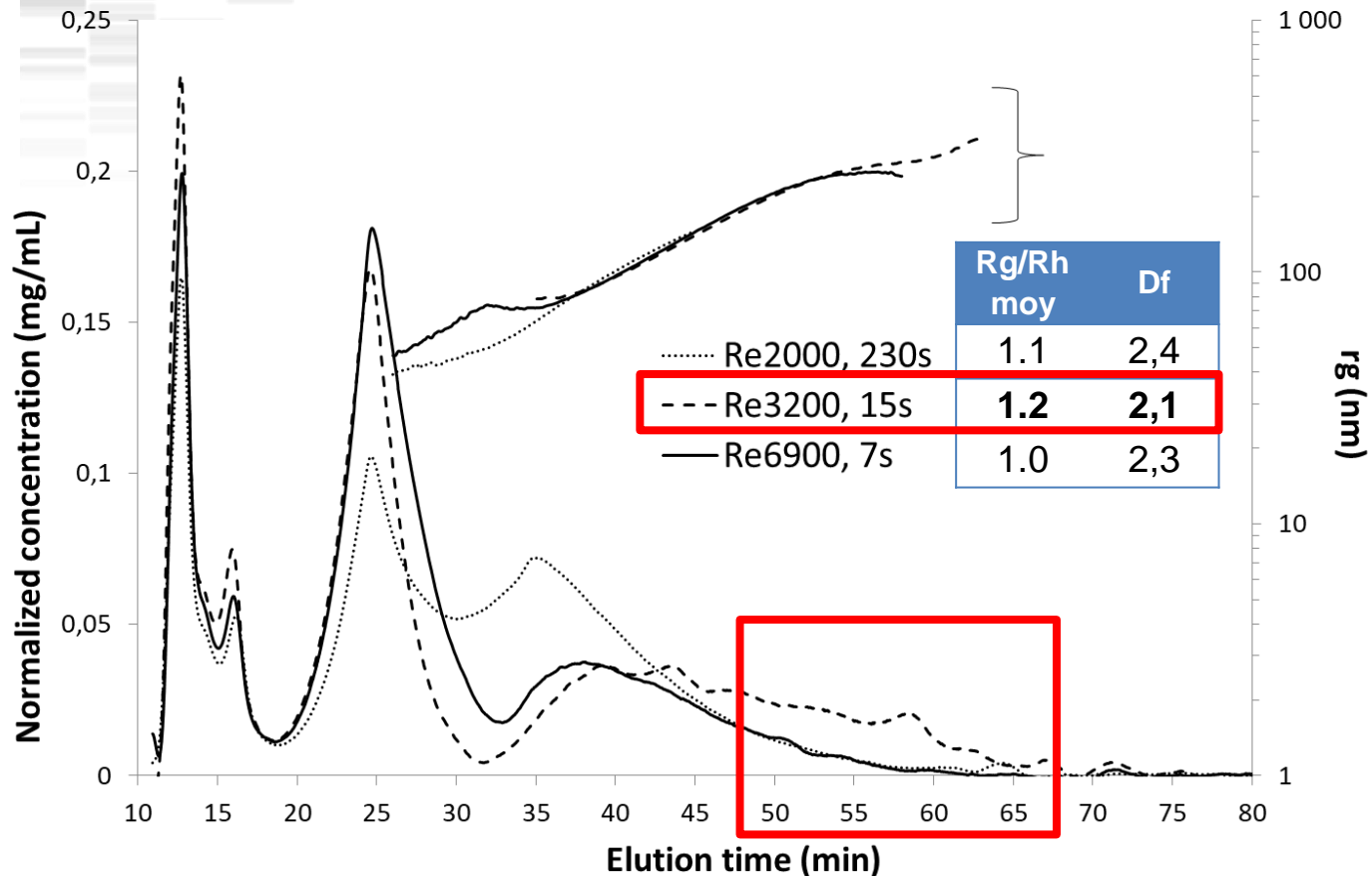
Shape factor ( $R_g/R_h$ )  
(0,78 for homogeneous sphere to 2,36 for stiff rod\*)

Fractal dimension  
(1 for rod to 3 for sphere\*\*)



\*Brewer 2011  
\*\*Loiseleux 2017

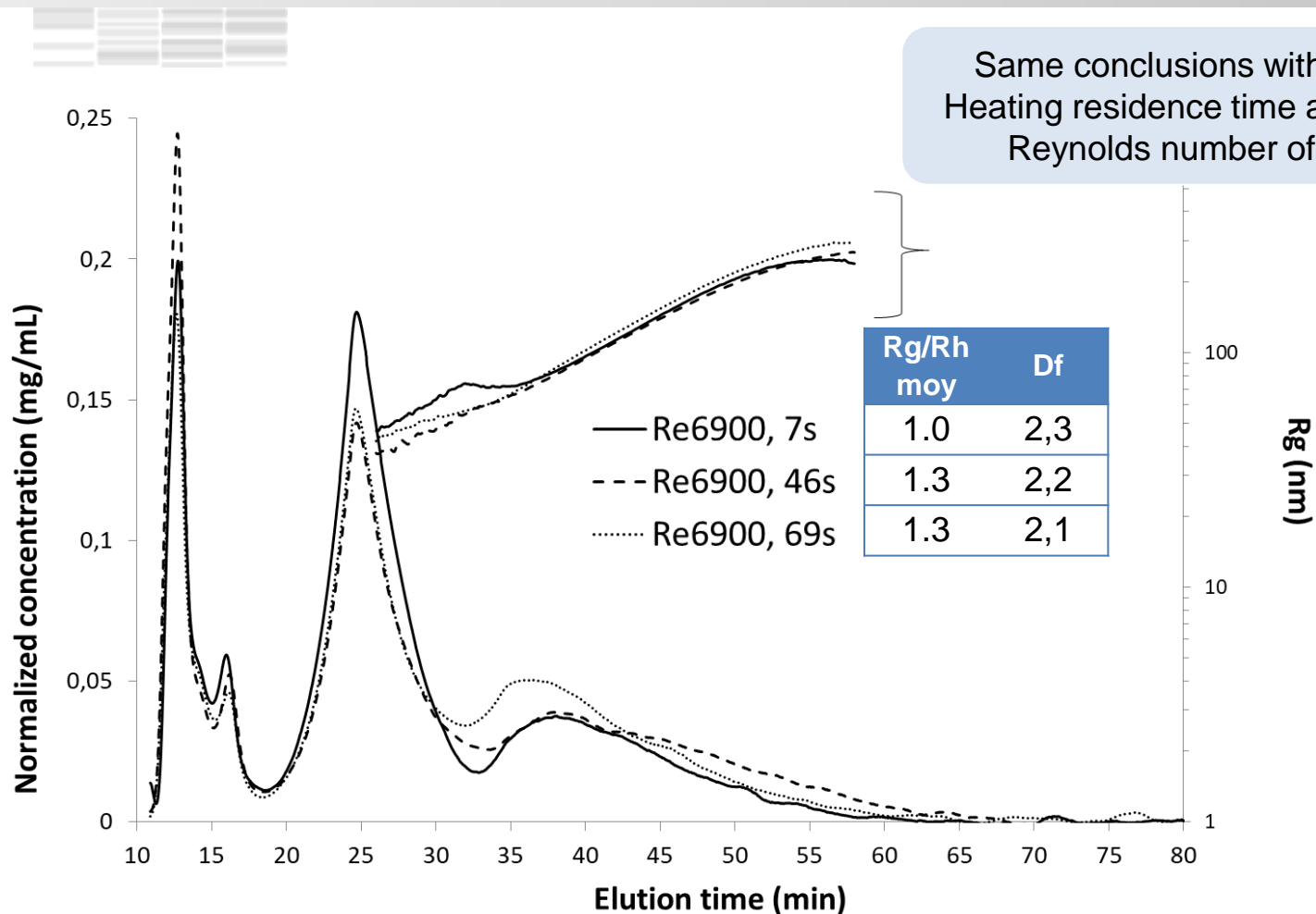
# AGGREGATES SHAPE AND SIZE ARE MODIFIED IN INTERMEDIATE FLOW REGIME



A more **opened structure** and an increase of aggregates **size** is obtained in **transient flow regime**



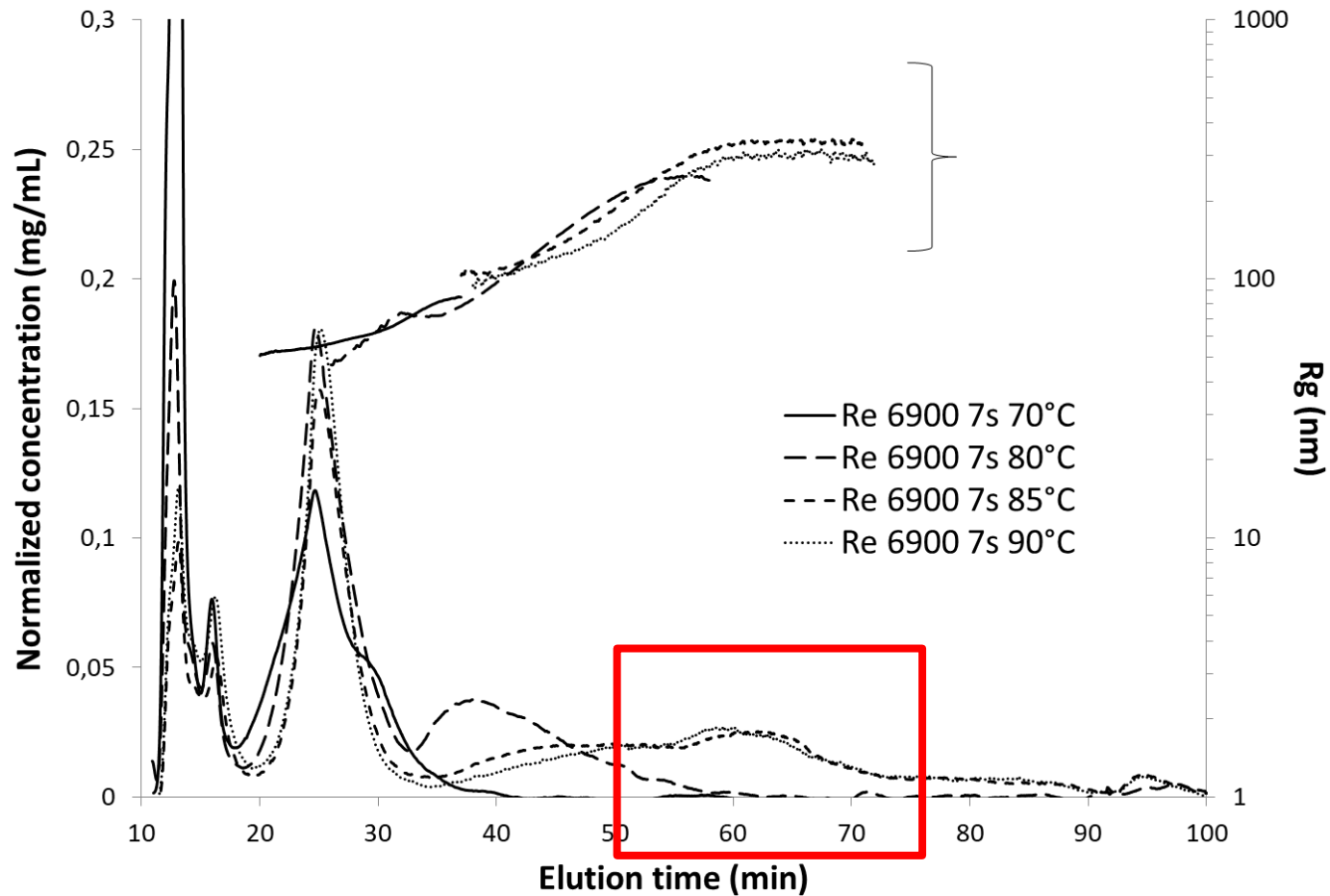
# HEATING RESIDENCE TIME HAVE NO IMPACT



Same conclusions with varying Heating residence time at constant Reynolds number of 2000.

**Heating residence time has no impact on aggregate size compared to flow regime in the range investigated.**

# HEATING TEMPERATURE MAINLY INFLUENCE AGGREGATE SIZE



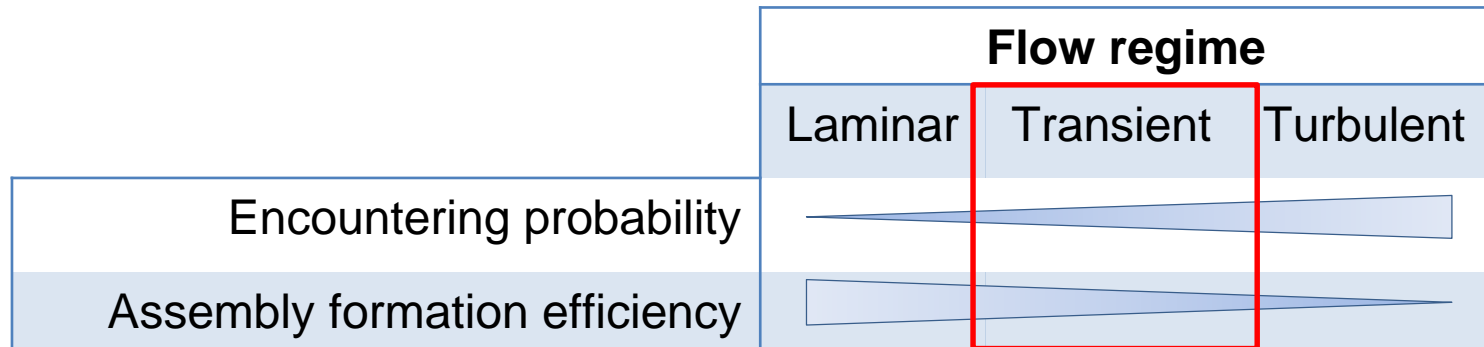
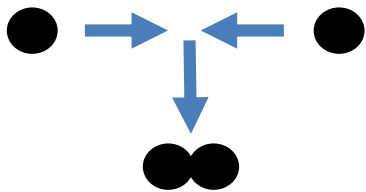
Formation of **larger aggregates** at a temperature up to **85°C**.

# MECHANISMS INVOLVED IN THE FORMATION OF FRACTAL AGGREGATES BY CONTINUOUS PROCESSING

Simmons (2007) : The final size of aggregates depends on particle collision and breakage

Turbulent structure 100 to 400 times  $>$  Ag size (kolmogorov scale)

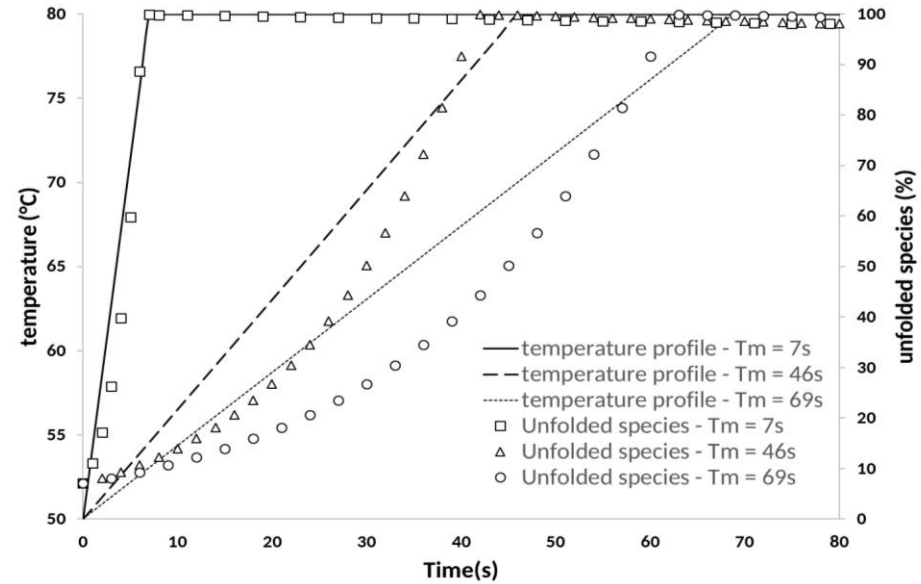
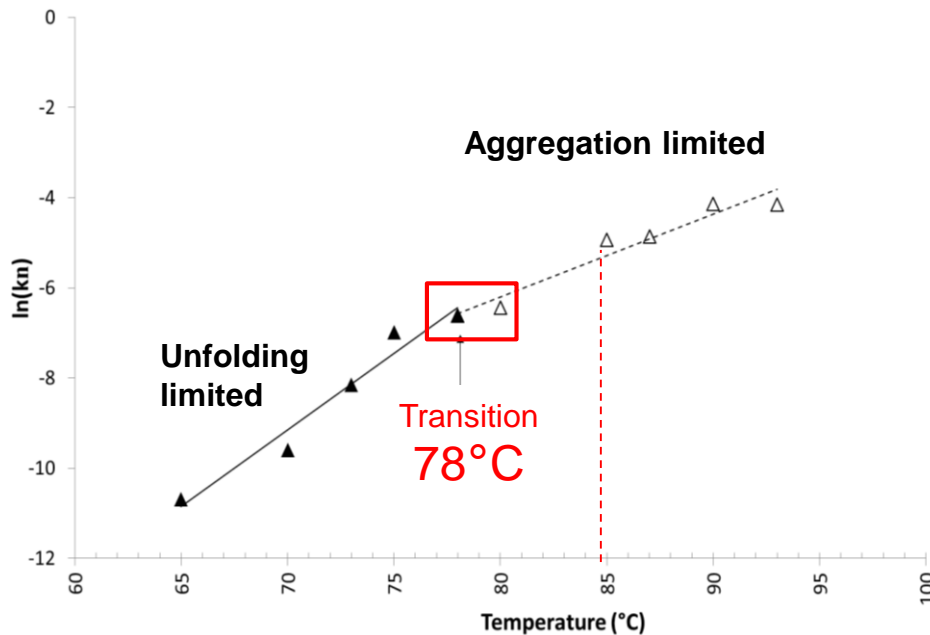
Association mechanism governs the growth of fractal aggregates.  
No breakage.



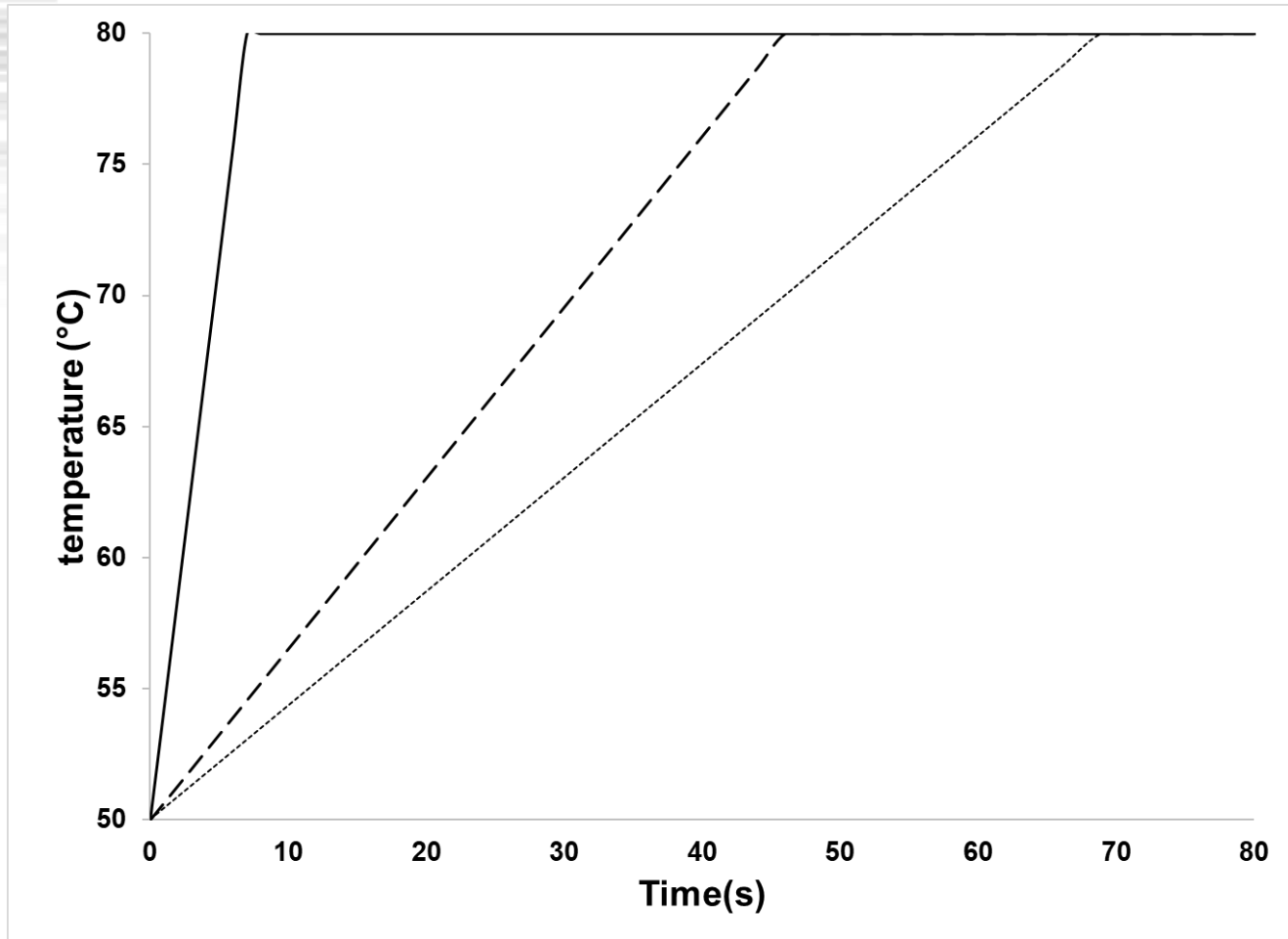
Association mechanism privileged

# MECHANISMS INVOLVED IN THE FORMATION OF FRACTAL AGGREGATES BY CONTINUOUS PROCESSING

Whatever the heating residence time, **100% of  $\beta$ lg is unfolded** at the exit of the heating zone. No additional reactive material should be expected while **increasing heating residence time**



At 85°C, the unfolding of reactive  $\beta$ lg is instantaneous and non limiting, resulting in the formation of **larger aggregates**.



# CONCLUSIONS

Physicochemical parameters

SCALE UP

Process parameters

Flow regime

Transient regime : ↗ Aggregate size  
↗ Structure opening

No breakage

Heating residence time

100 %  $\beta$ lg unfolded at the exit of the heating zone  
No impact of heating residence time

Outlet heating temperature

$T \geq 85^\circ\text{C}$  : Unfolding of  $\beta$ lg instantaneous and non limiting  
↗ Aggregate size / Apparition of a 4<sup>th</sup> population

Fractal aggregates size control

Different functional properties

Texture  
Heat stability  
Emulsion stability

New healthy and more natural products.

Milk Valley

PROFIL



***Thank you for your attention***

