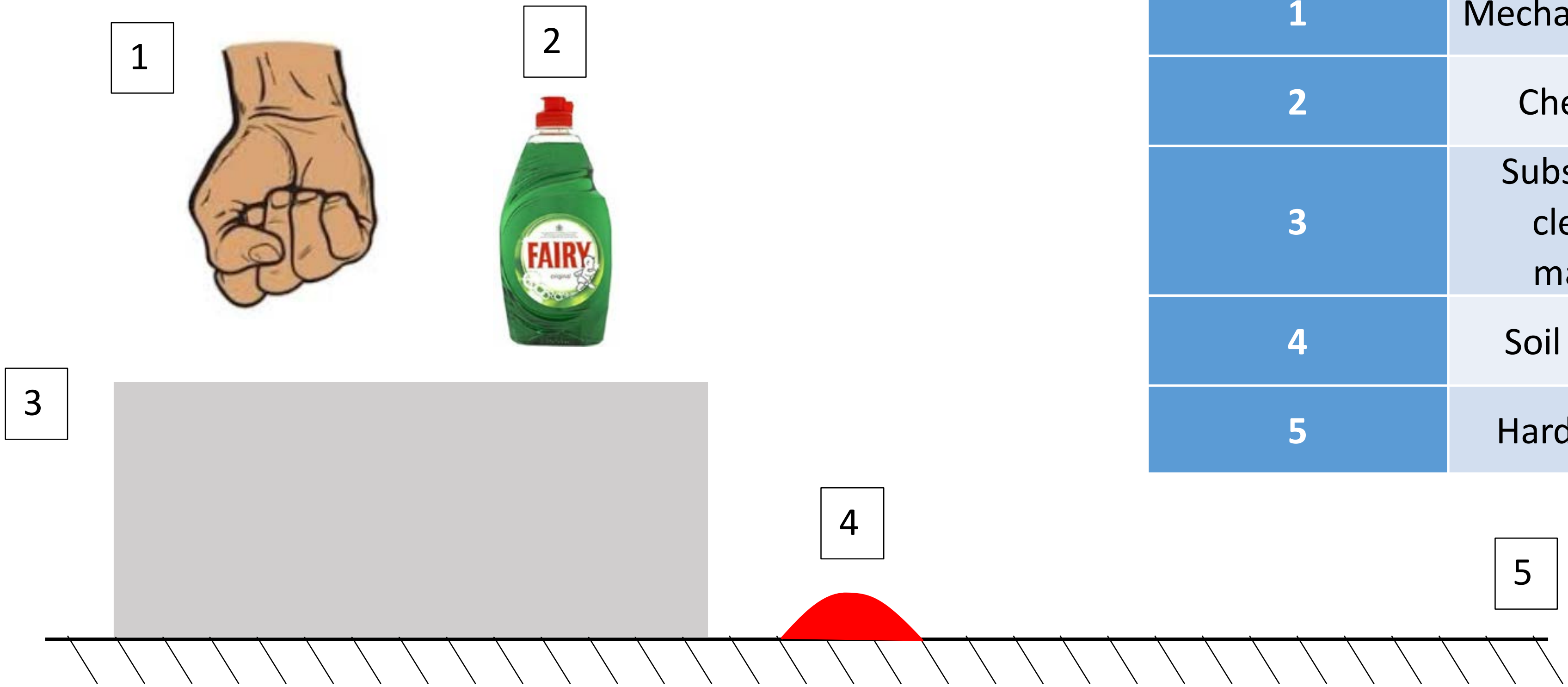
Understanding chemomechanical interactions during hard surface cleaning processes

Perrakis Bistis

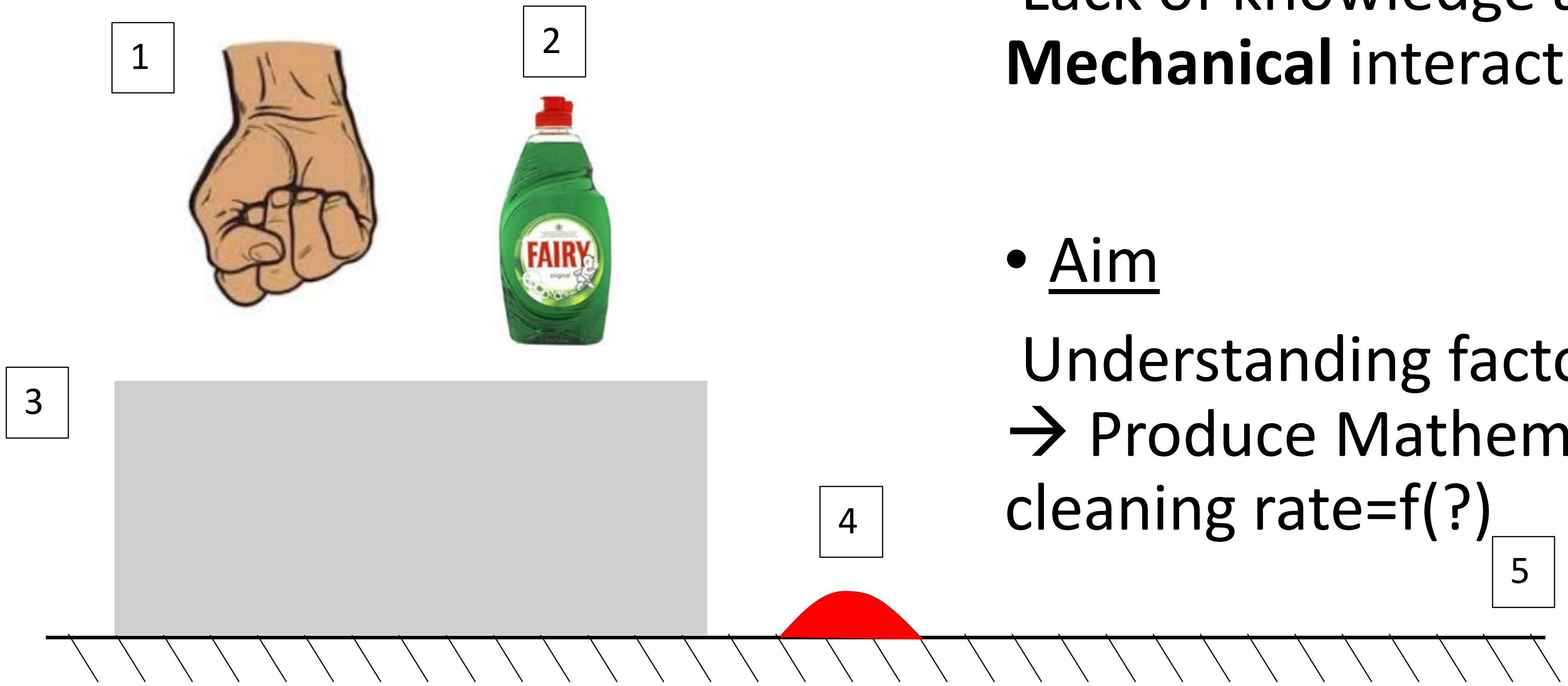
Hard surface cleaning

Hard surface cleaning – Aim of the project



Factors	Name	Formulation Control
1	Mechanical force	No
2	Chemistry	Yes
3	Substrate or cleaning material	Yes
4	Soil or Stain	Modelling
5	Hard Surface	Modelling

Hard surface cleaning – Aim of the project



- <u>Challenge</u>

Lack of knowledge about **Chemical** + **Mechanical** interactions with surface

- <u>Aim</u>

Understanding factors that affect cleaning → Produce Mathematical **Models**: cleaning rate=f(?)

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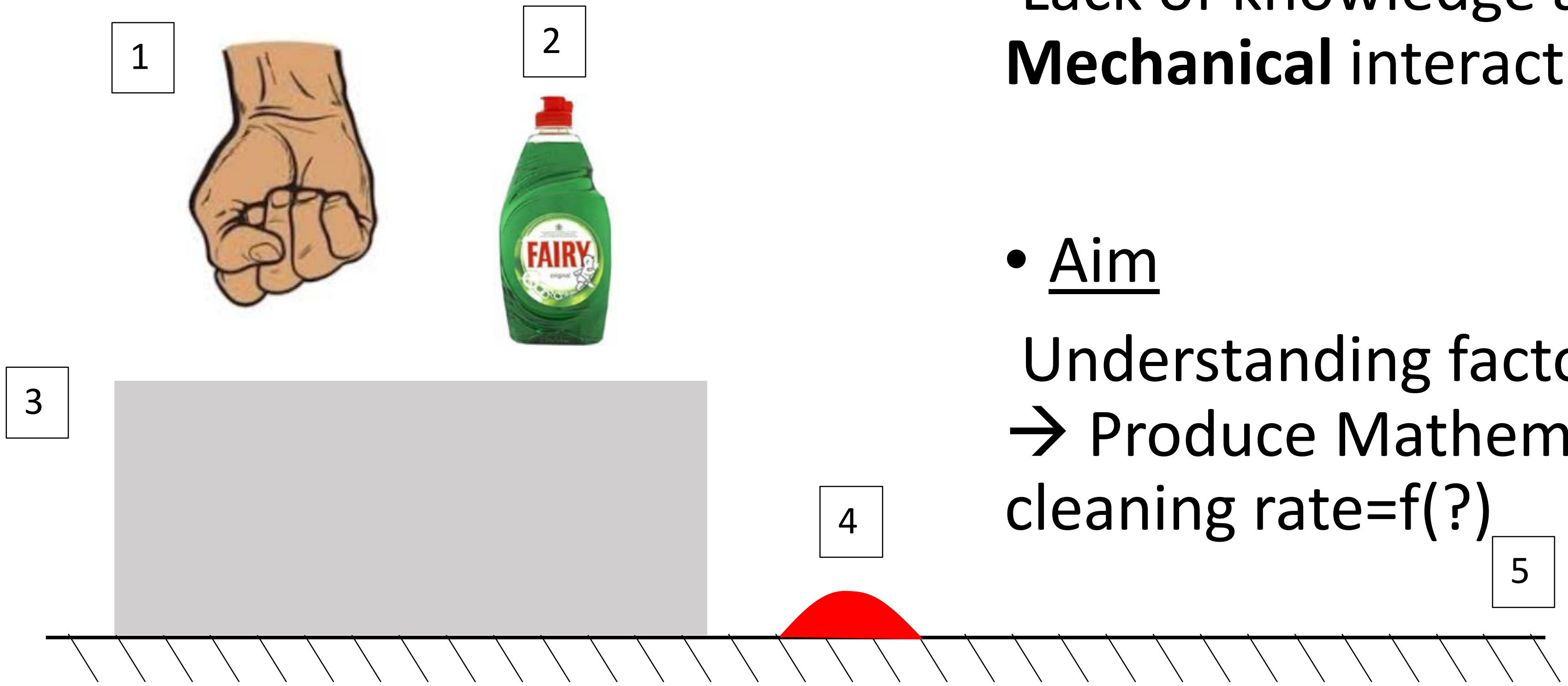

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Background

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- Cleaning → Hard surface cleaning / Soft surface cleaning

- Tribology → Study of friction, wear and lubrication

Force on the stain | Of the stain | Between cleaning material and stain

-Key tool to study mechanical interactions during cleaning

- Previous Projects→ Developed a soil → Main outcome 1: Surfactants achieve to weaken cohesive strength more than adhesive strength Main outcome 2: Hydration main cleaning factor[1]

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Friction → Force on the stain

Wear → Of the stain

Lubrication → Between cleaning material and stain

-Key tool to study mechanical interactions during cleaning

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[1] Lütkenhaus D. Engineering Understanding of Cleaning : Effect of Chemistry and Mechanical Forces on Soil Removal. 2017.

Factors affecting cleaning

- Main Factors that affect Cleaning:

-Temperature (T),

-Applied Pressure (P),

-Substrate Surface (A),

-Hardness of soil (H),

-Shear rate (γ),

-Chemistry:

1. Detergent Concentration (C)
2. Surfactant Action

Cleaning rate = f(T,P,A,H,γ,C)

H= f(viscosity, adhesive cohesive strength, Young's modulus)

Equipment used to obtain these parameters

- Mini Traction Machine → measures Traction Coefficient

- Micromanipulation → measures Adhesive & Cohesive strength
- Indentation → measures Young's Modulus

- Rheometer → Viscosity

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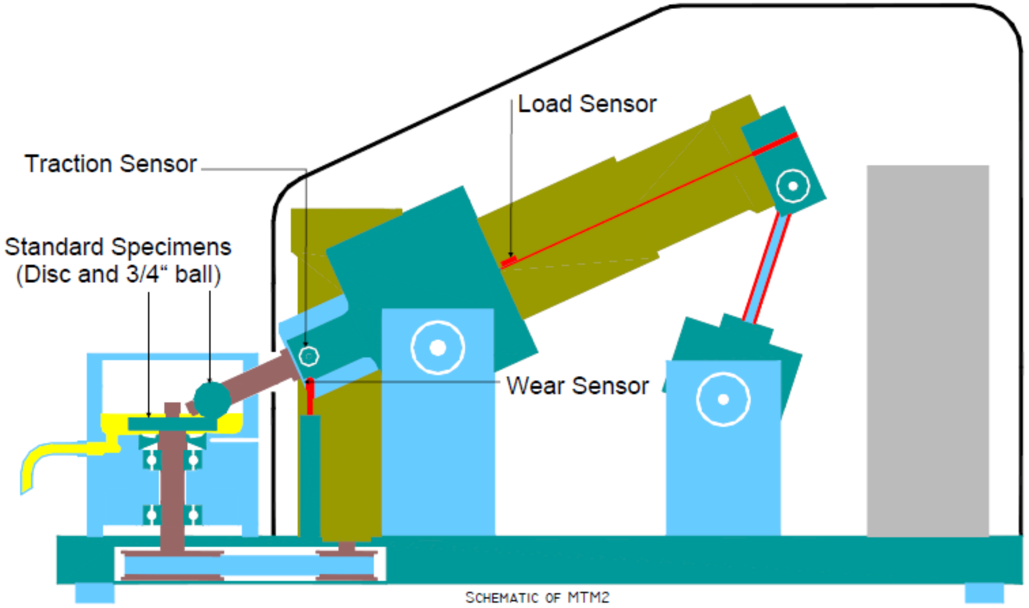
Mini Traction Machine

- Measures traction coefficient
- Main parts: Rotating ball – Rotating disc
- Controlled Factors: Load W, speed U, Slide Role Ratio SRR, Temperature T
- Frictional force F measured by transducer →traction coefficient μ=F/W

$$SRR = \frac{U_{disc} - U_{ball}}{U}$$

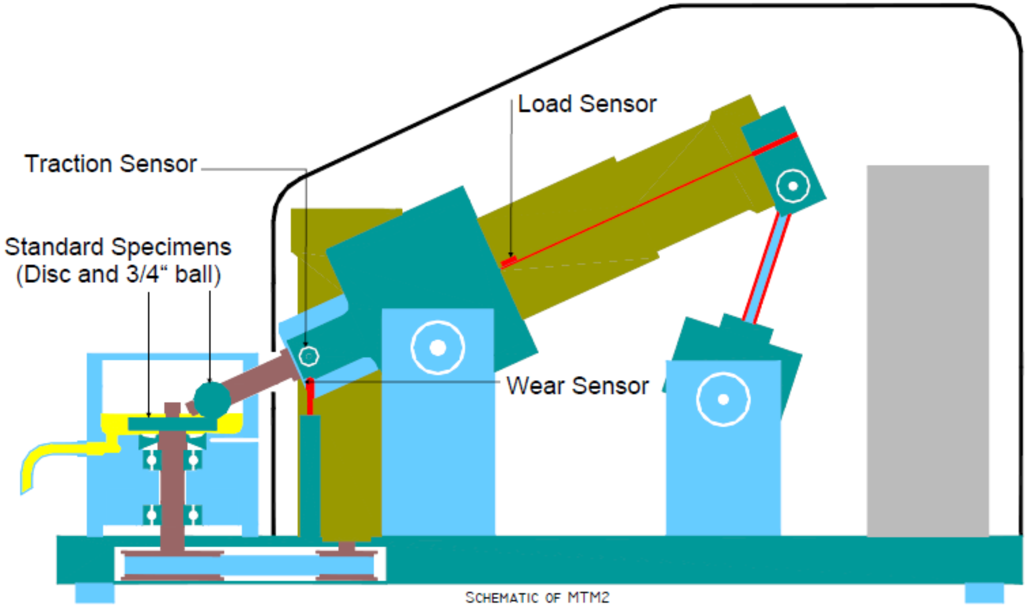


Garrec D A and Norton I T 2012 The influence of hydrocolloid hydrodynamics on lubrication *Food Hydrocoll.* **26** 389–97

Mini Traction Machine

Why MTM?

- Friction coefficient values, while using mechanical force and changing various parameters
- Prove that MTM can be used for cleaning experiments
- An effort to correlate traction (friction) coefficient with cleaning rate



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Sample preparation + Experimental procedure

	Mass (g)
Water	~75
Fat	~0.5
Carbohydrate	17.1
Fibre	2.6
Protein	4.4
Salt	0.38

Sample preparation + Experimental procedure

- (1,2) Position puree around disc with a spatula and sample loader (picture 2-3) (~1.5 g), measure weight and place in the oven (110ºC 1h)
- (3) After oven, measure weight (picture 5)
- (4) Disc in MTM chamber (parameters: Load, Speed, Mass, Detergent Concentration)
- (5) During the experiment (liquid samples for UV-Vis measurements)


1


2

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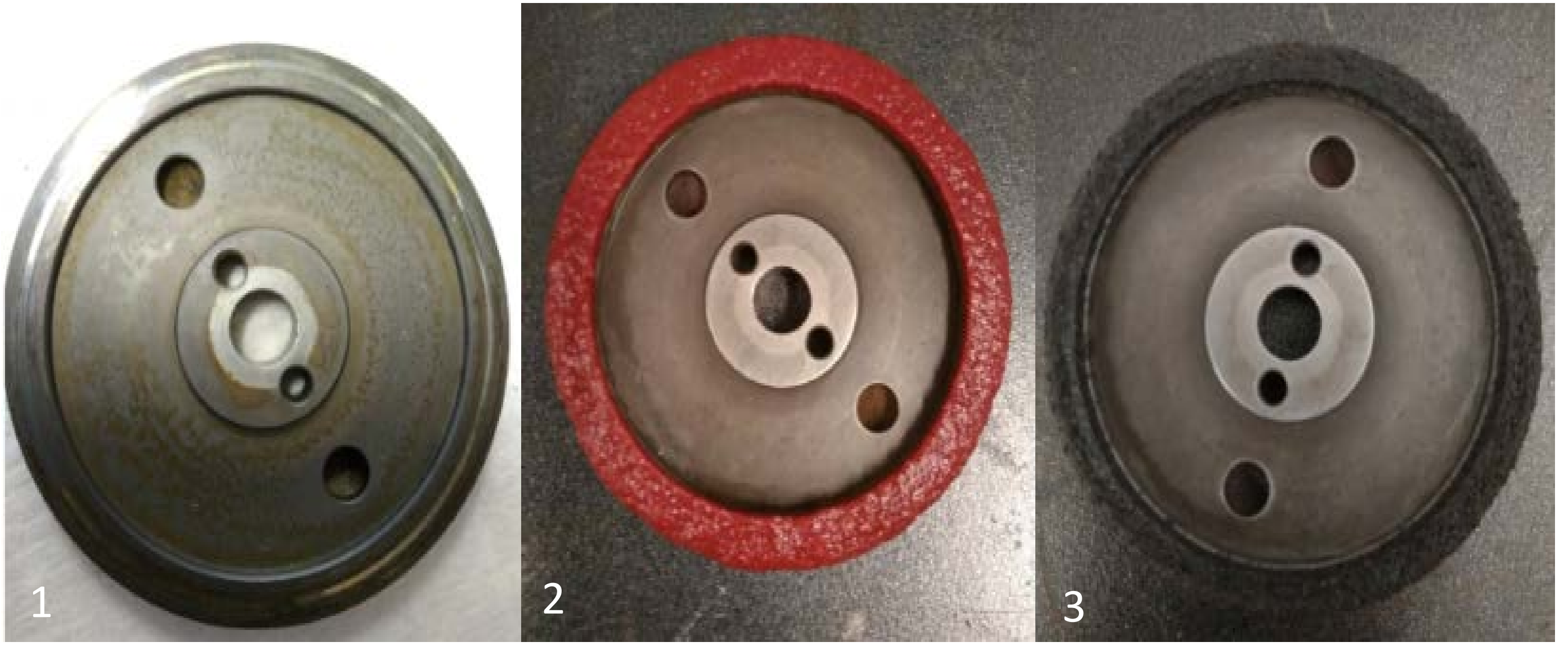

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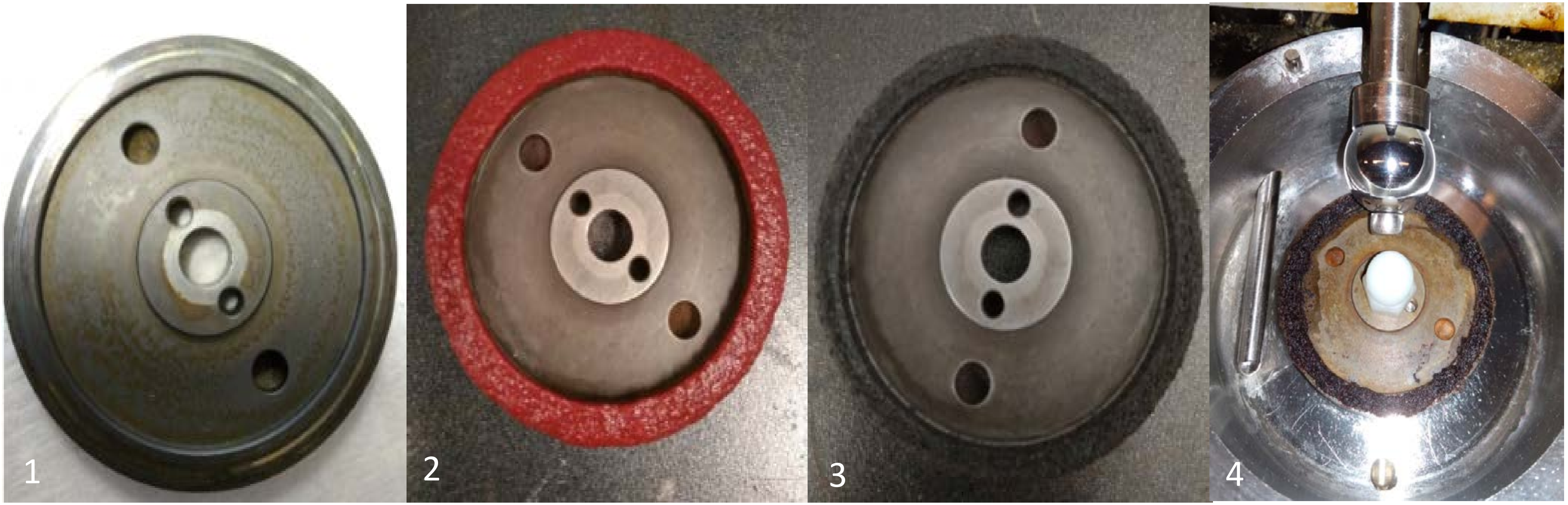

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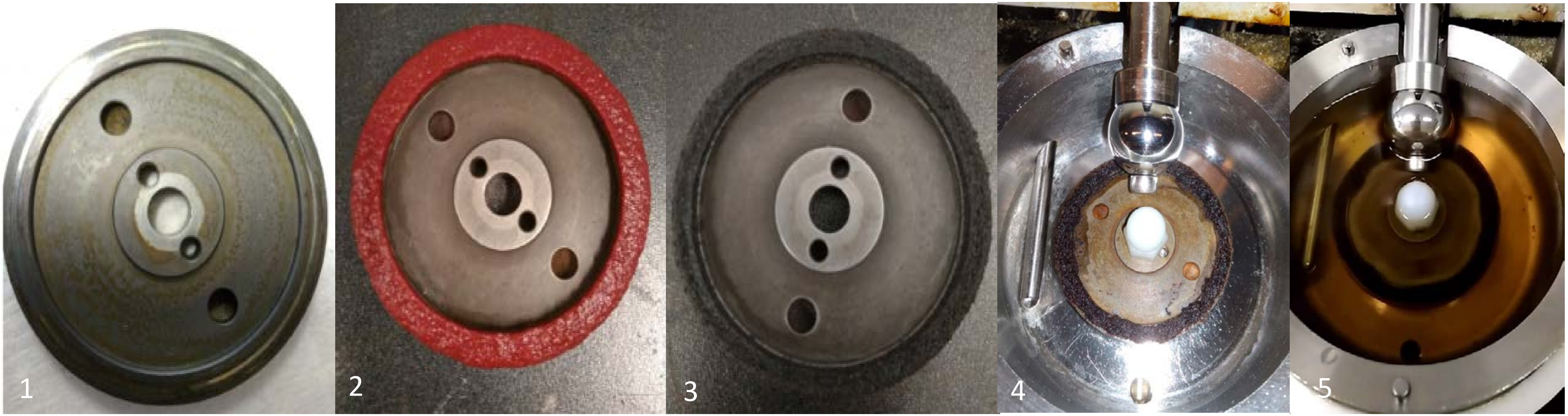

Cleaning rate

- Cleaning rate calculations

$m_o = m_2 - m_1$, $m = m_3 - m_1$

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60°C, 1 day

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$m_o = m_2 - m_1$, $m = m_3 - m_1$

Dry ← 60^{o}C, 1 day

Cleaning rate

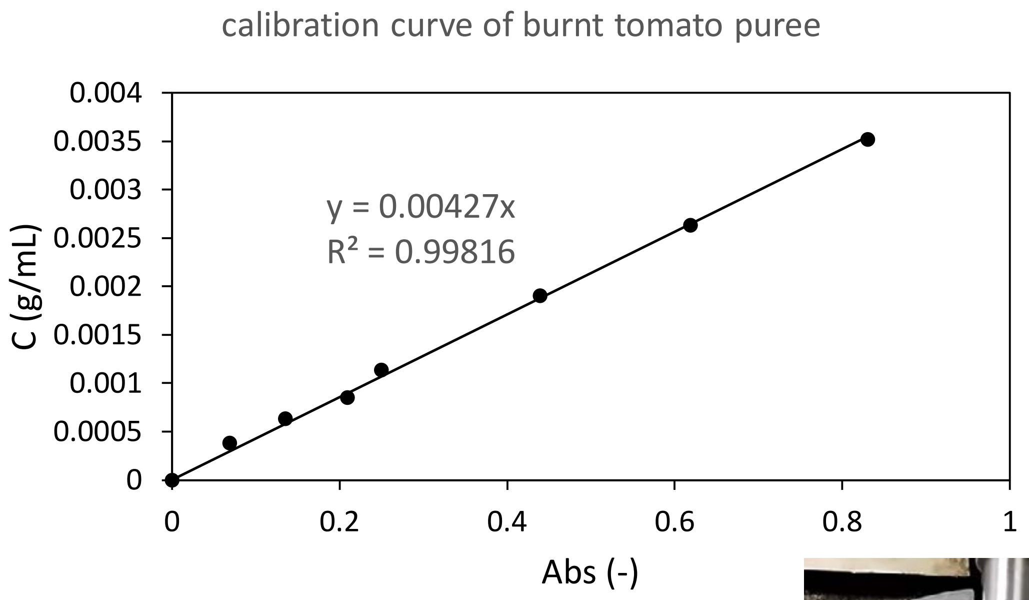
- Cleaning rate calculations

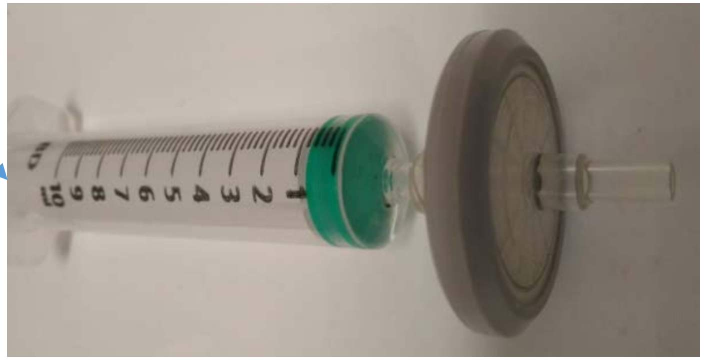
$m_o=m_2-m_1$, $m=m_3-m_1$

Dry ⟵ 60°C, 1 day

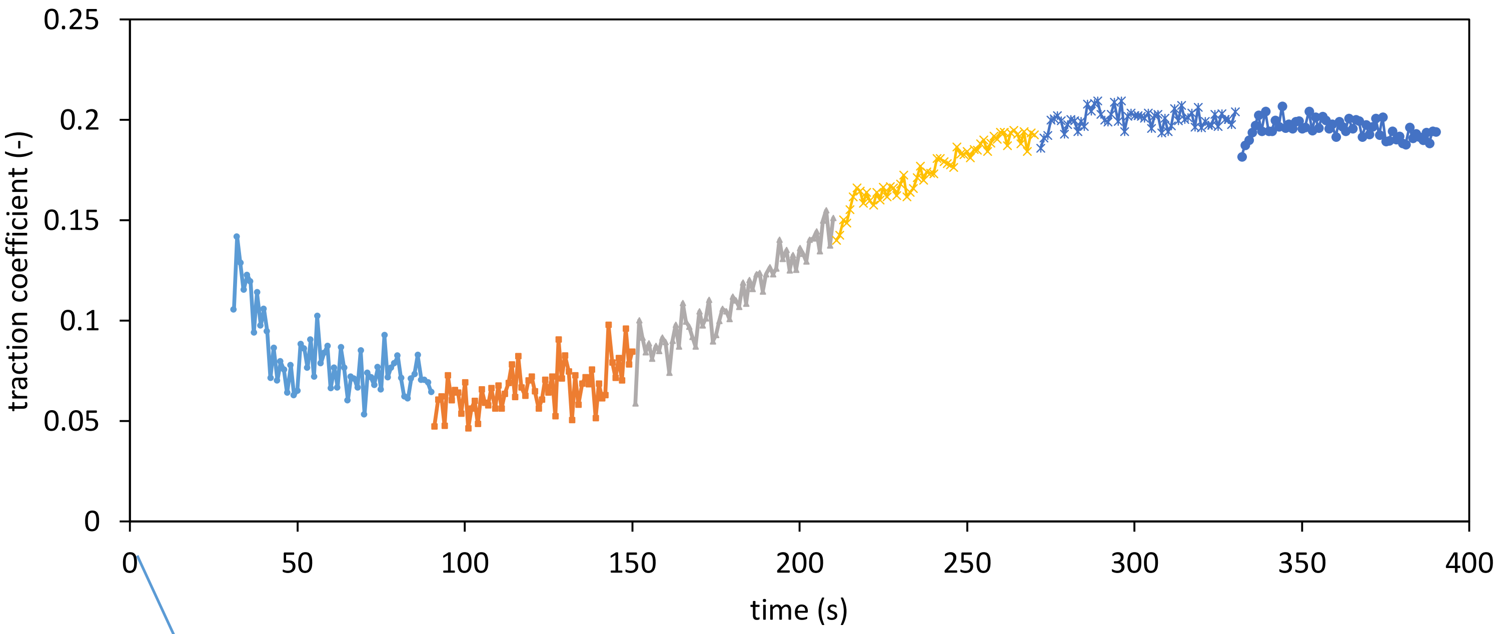
UV-Vis calculations

- Calibration curve for tomato puree (λ=480 nm)
- Liquid samples with syringe filters during the experiment
- UV-Vis measurements





Visual observation of the experiment



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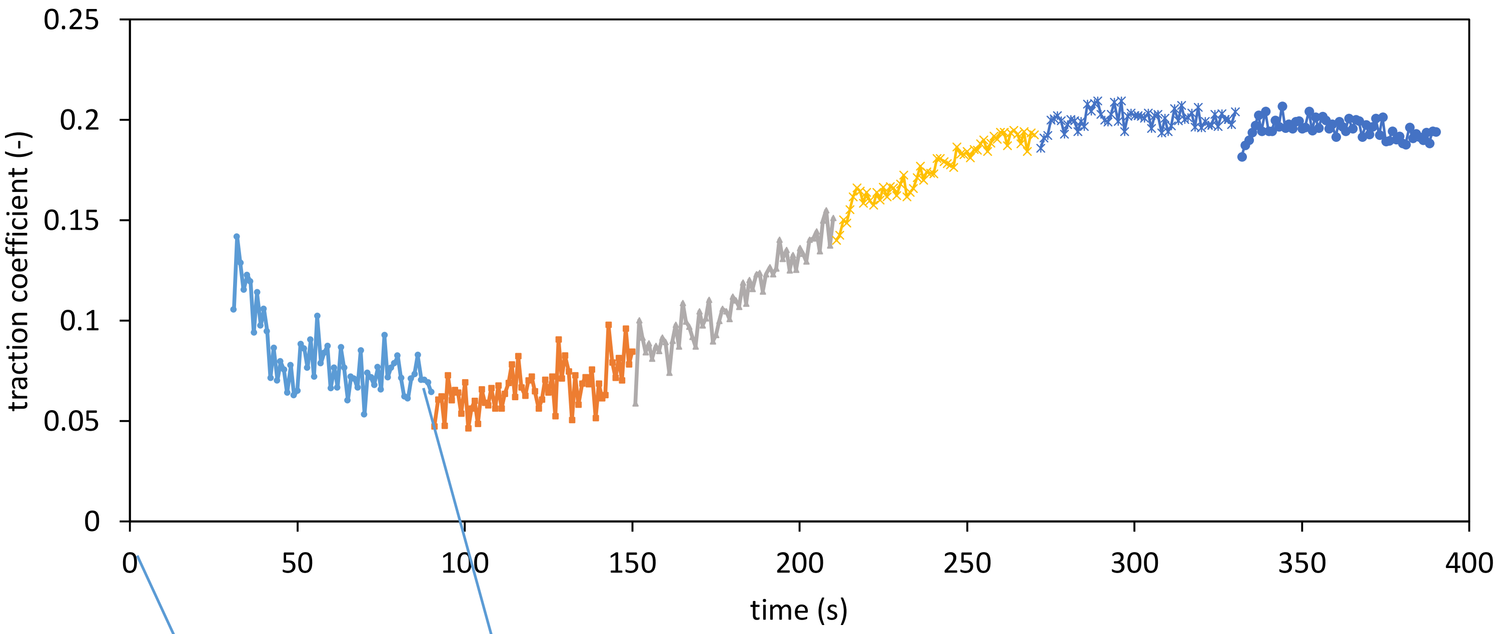

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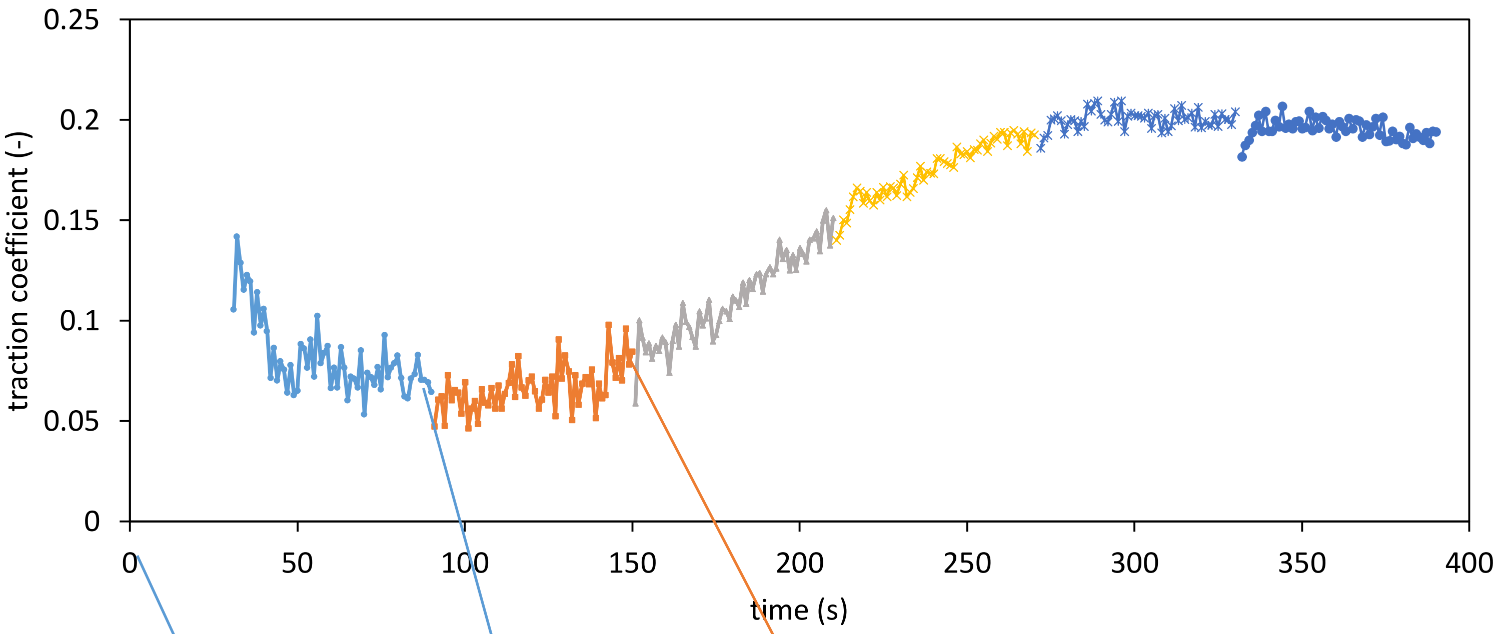

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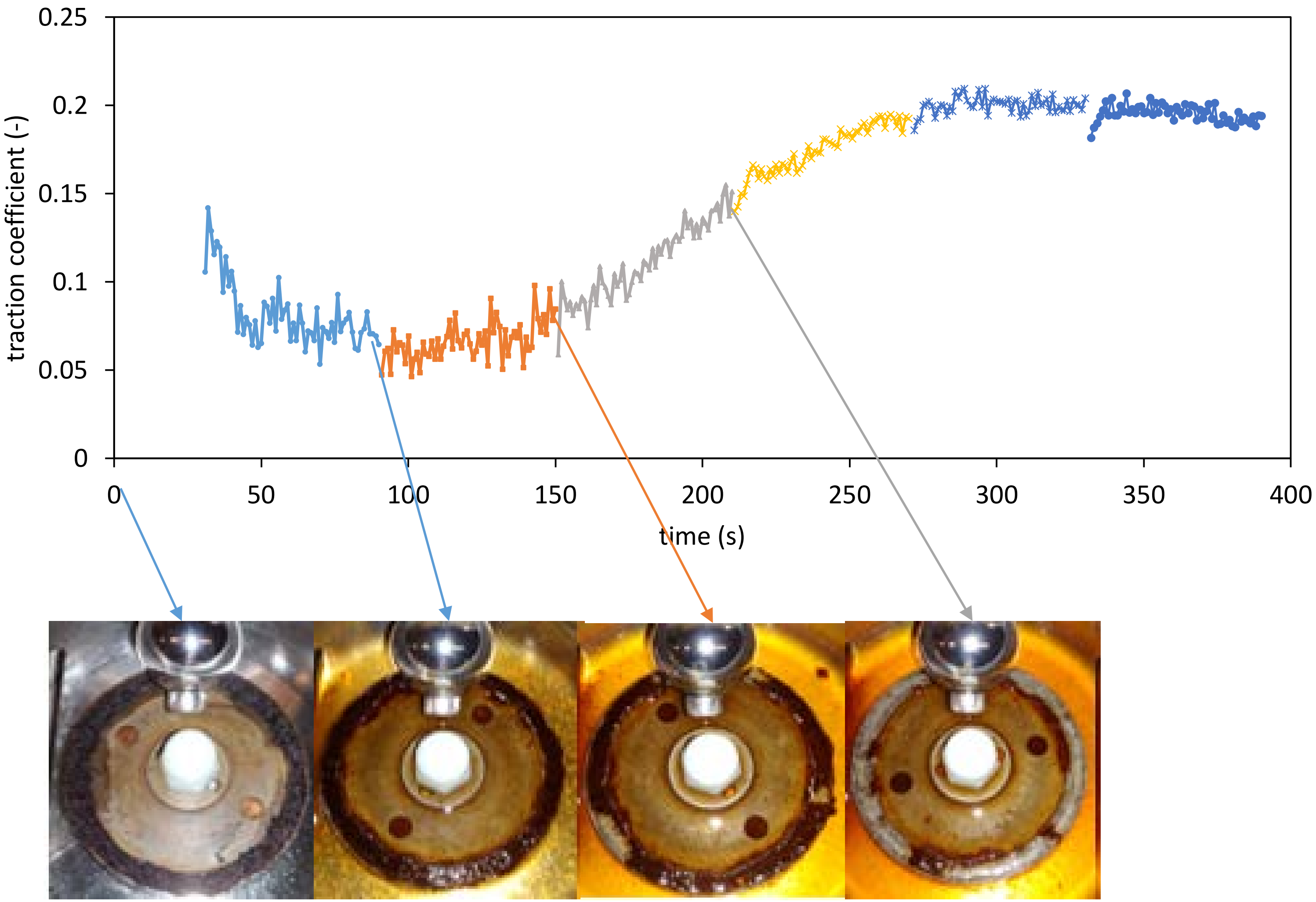

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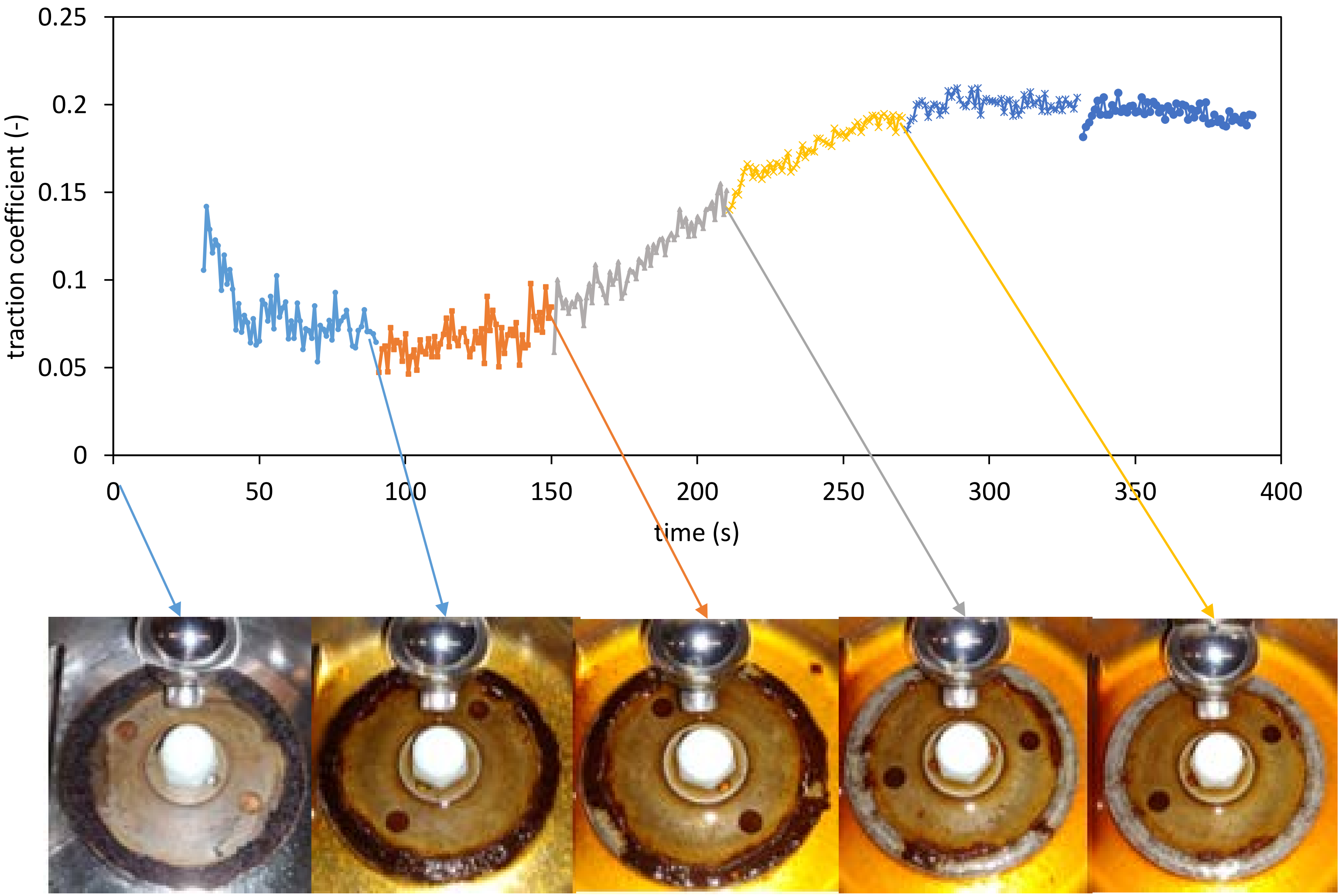
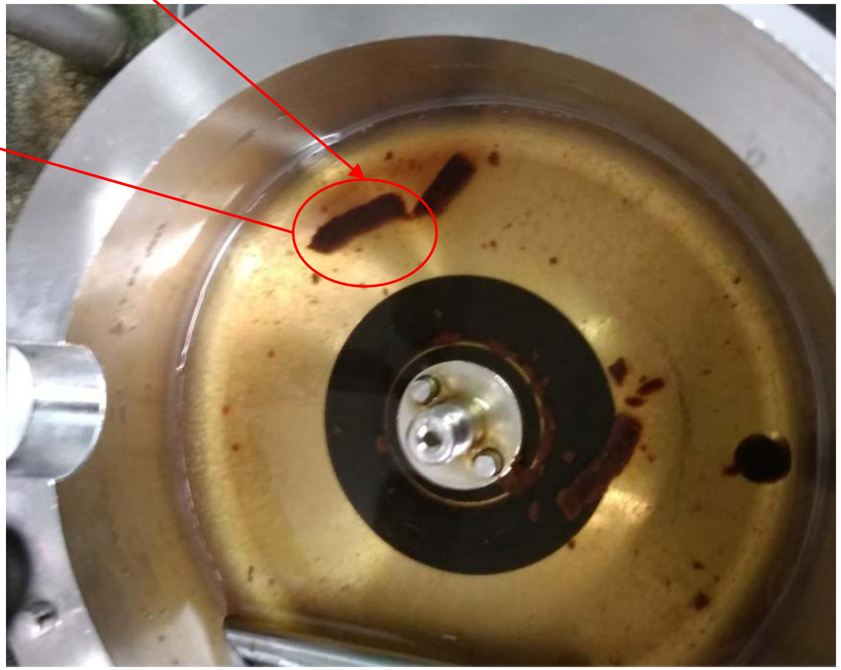


Cleaning mechanisms in MTM – Cleaning rate

Tomato fragments



Cleaning mechanisms in MTM – Cleaning rate

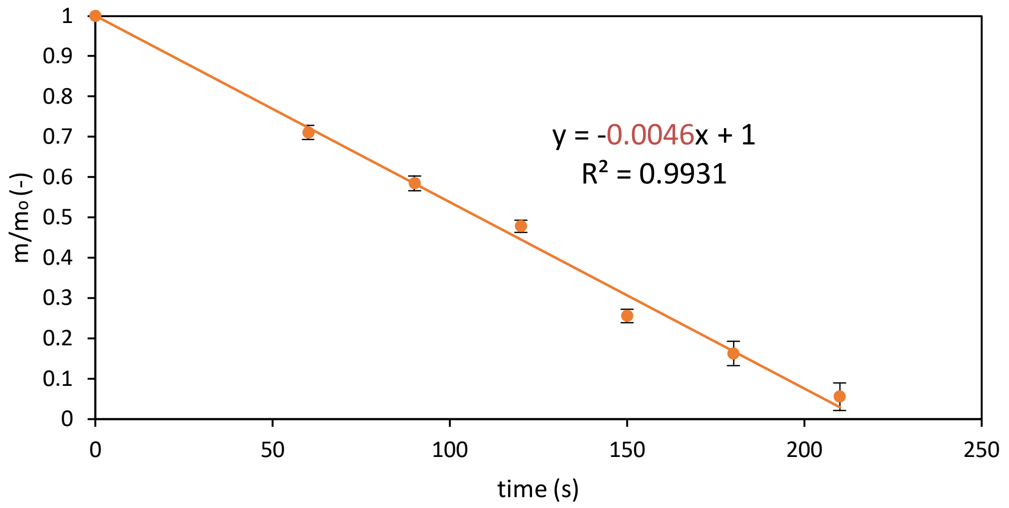
UV-Vis to measure cleaning mechanism contribution

Cleaning mechanisms in MTM – Cleaning rate

- 2 main cleaning mechanisms no chemistry:
- Dissolution
- Mechanical Removal

UV-Vis to measure cleaning mechanism contribution

- Cleaning rate = $\frac{d\left(\frac{m}{m_o}\right)}{dt}$



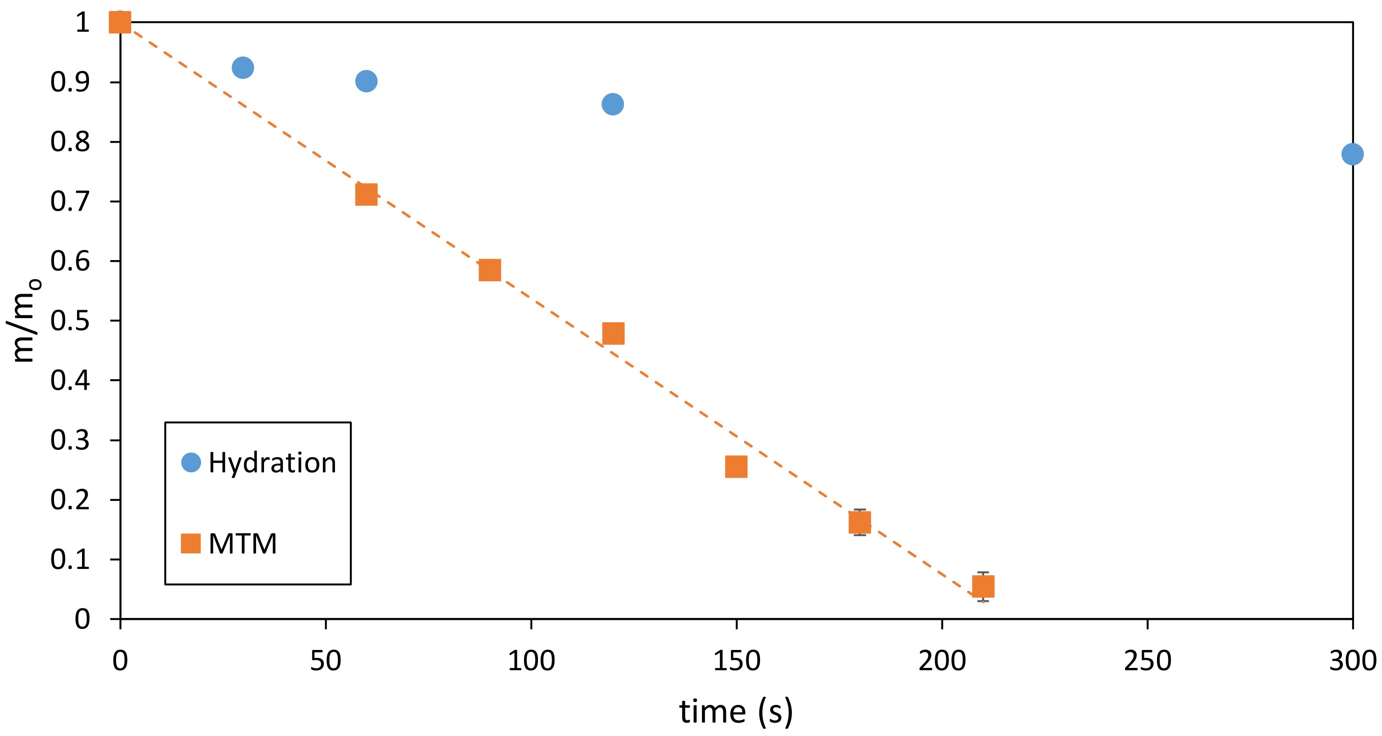
Hydration vs Mechanical removal

- <u>Hydration</u>

 Removed 20% in 5 min

- <u>+Mechanical force</u>

Should coexist → 100% removal in less than 5 min

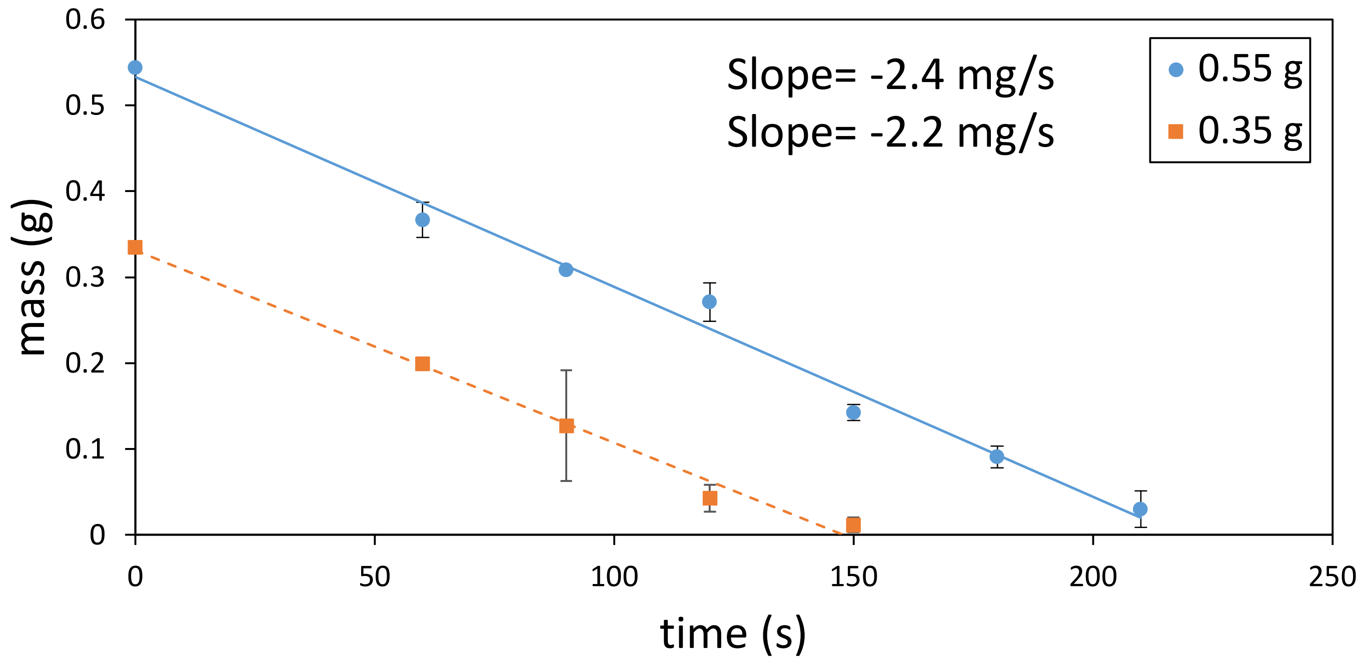


Parameter variation

- 1. <u>Mass of the tomato puree</u>
- 2. <u>Normal Load/Applied Pressure</u>
- 3. <u>Rolling Speed</u>
- 4. <u>Detergent Concentration</u>

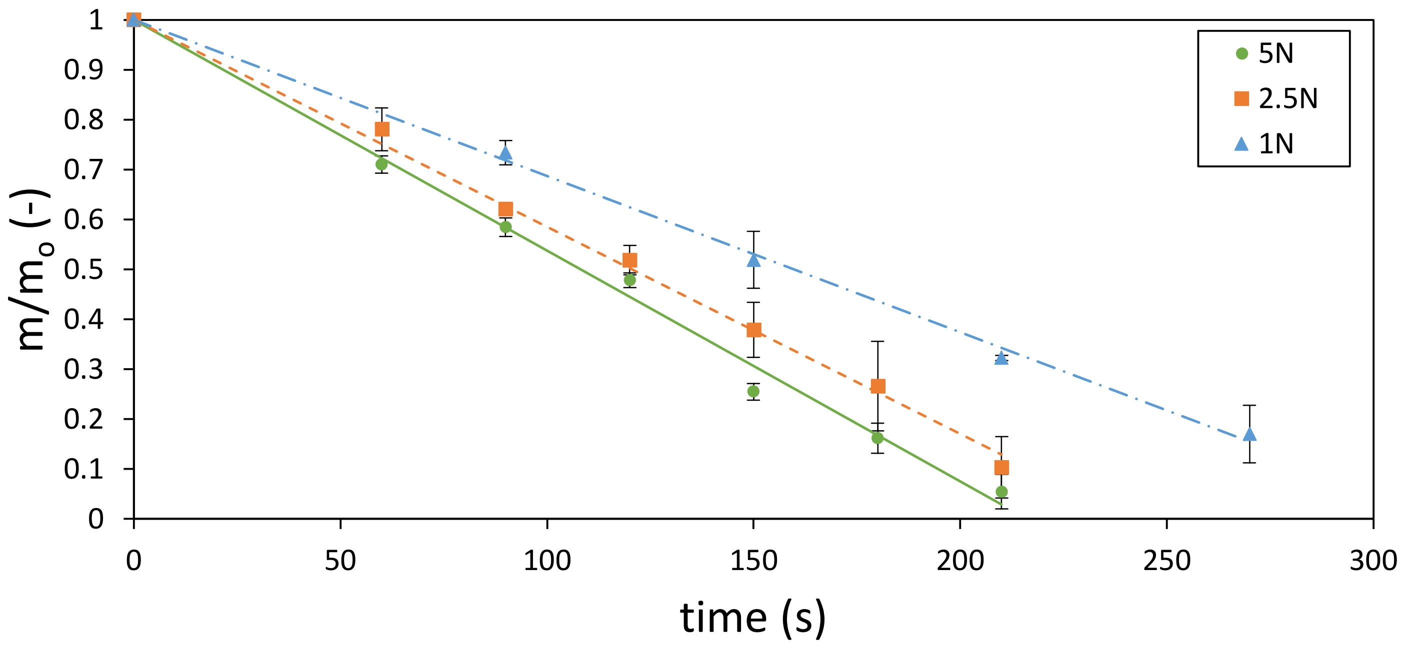
1. Mass of the tomato puree

- Slope=Cleaning rate (constant)
- Different masses ~= cleaning rates → Mass does not affect cleaning rate



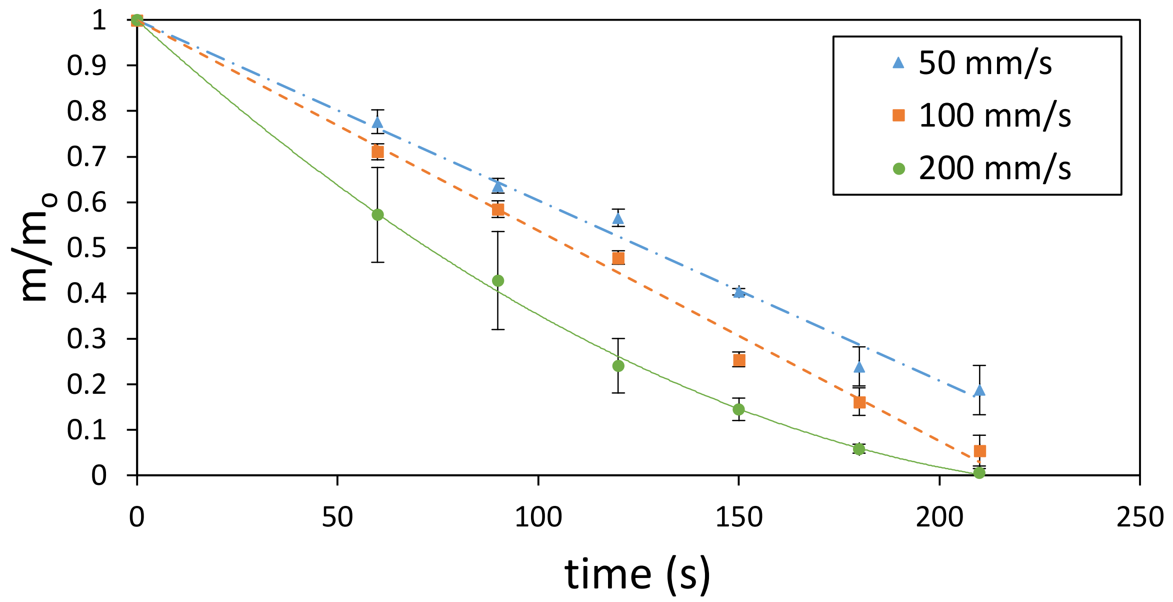
2. Normal Load/Applied Pressure

- Different load (1, 2.5, 5N or 260, 350 and 440 kPa)
- Increase of load → Increase of cleaning rate



3. Rolling Speed

- 200 mm/s → Not linear behaviour
- Increase of speed → Increase of cleaning rate



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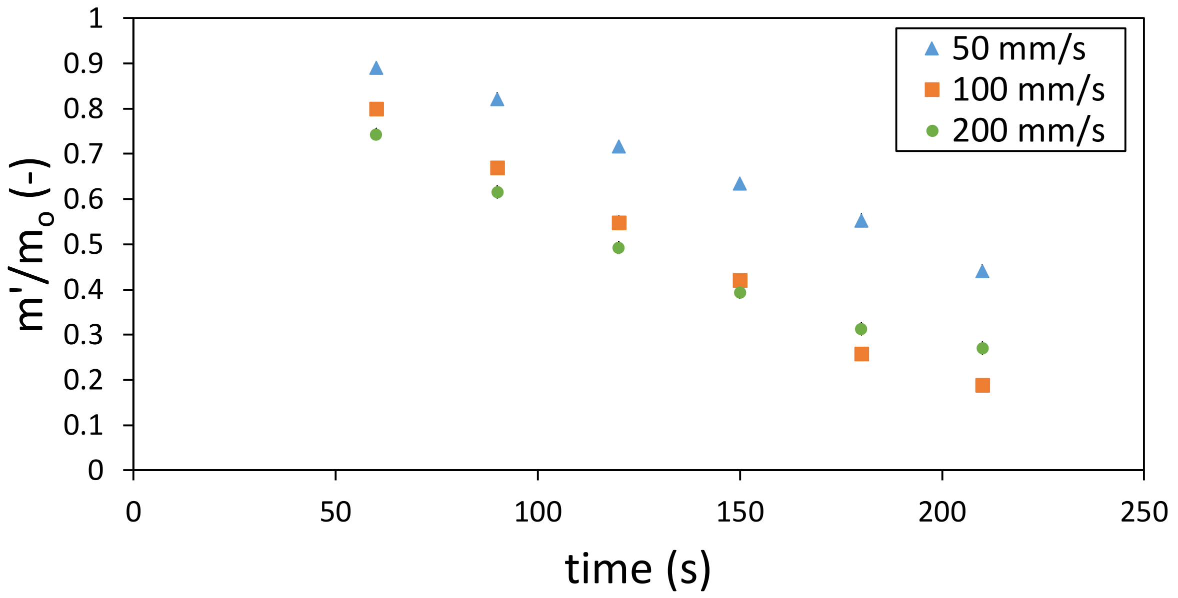
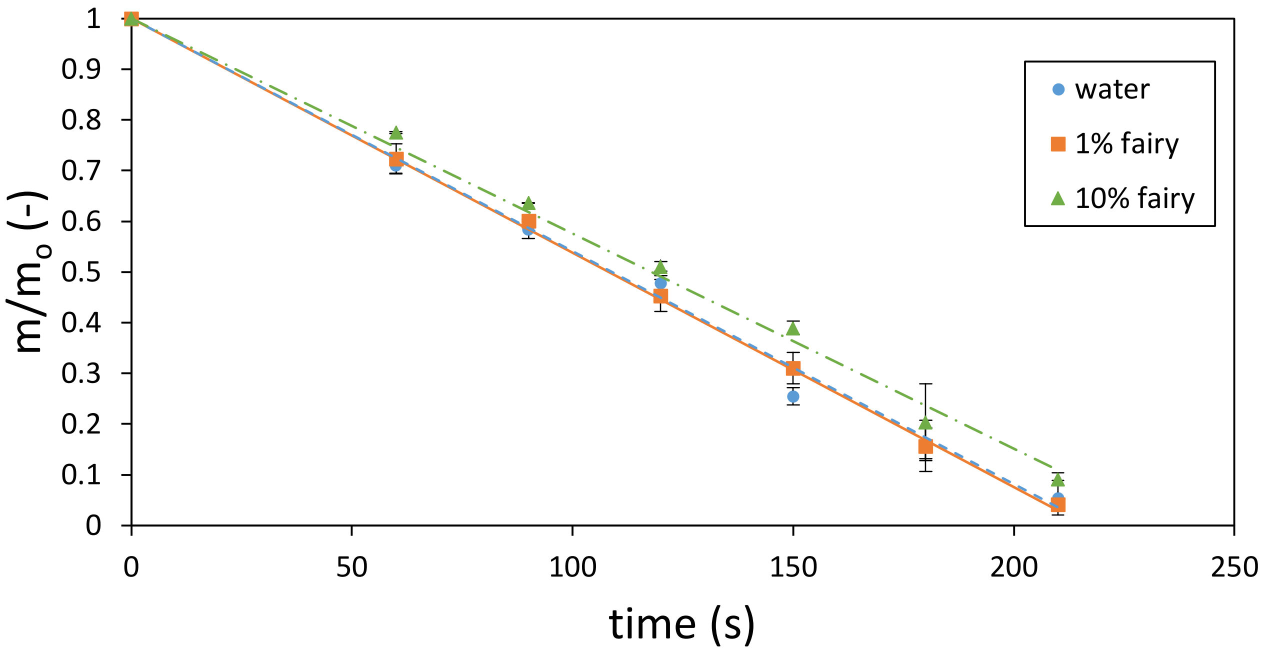


4. Detergent Concentration (1)

- Better cleaning rate for detergent was expected but it was not the case
- Lubrication effect seems to hinder cleaning rate for detergent cases



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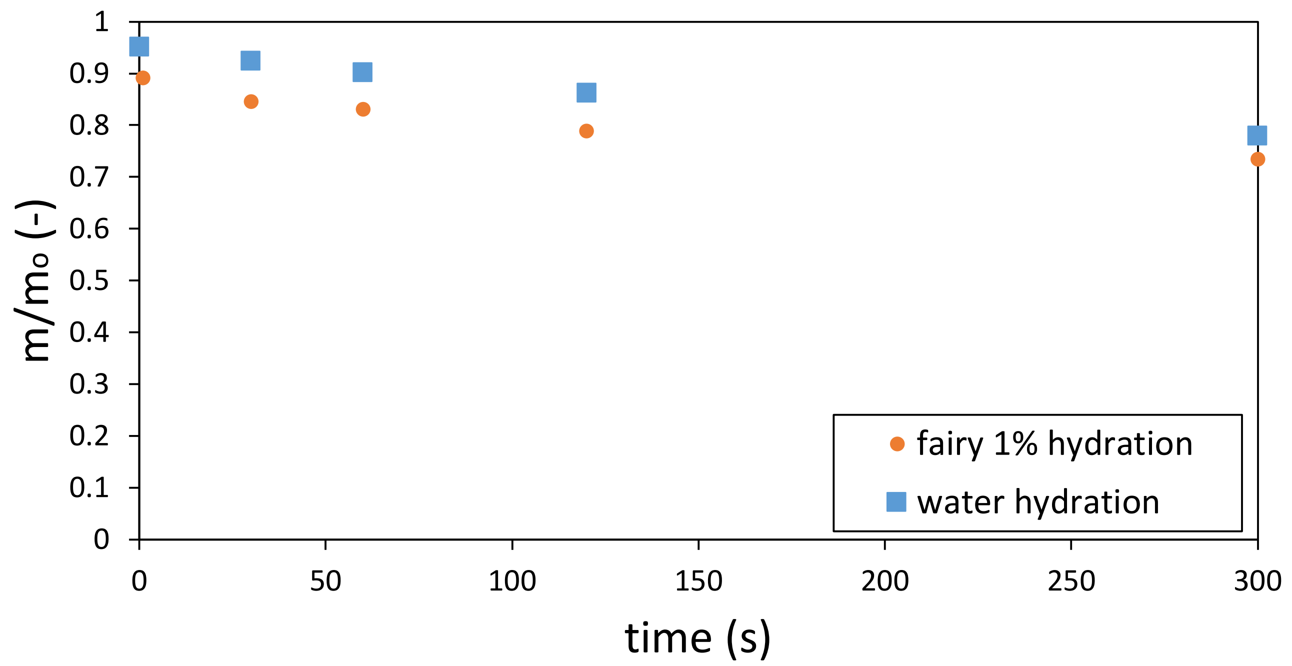
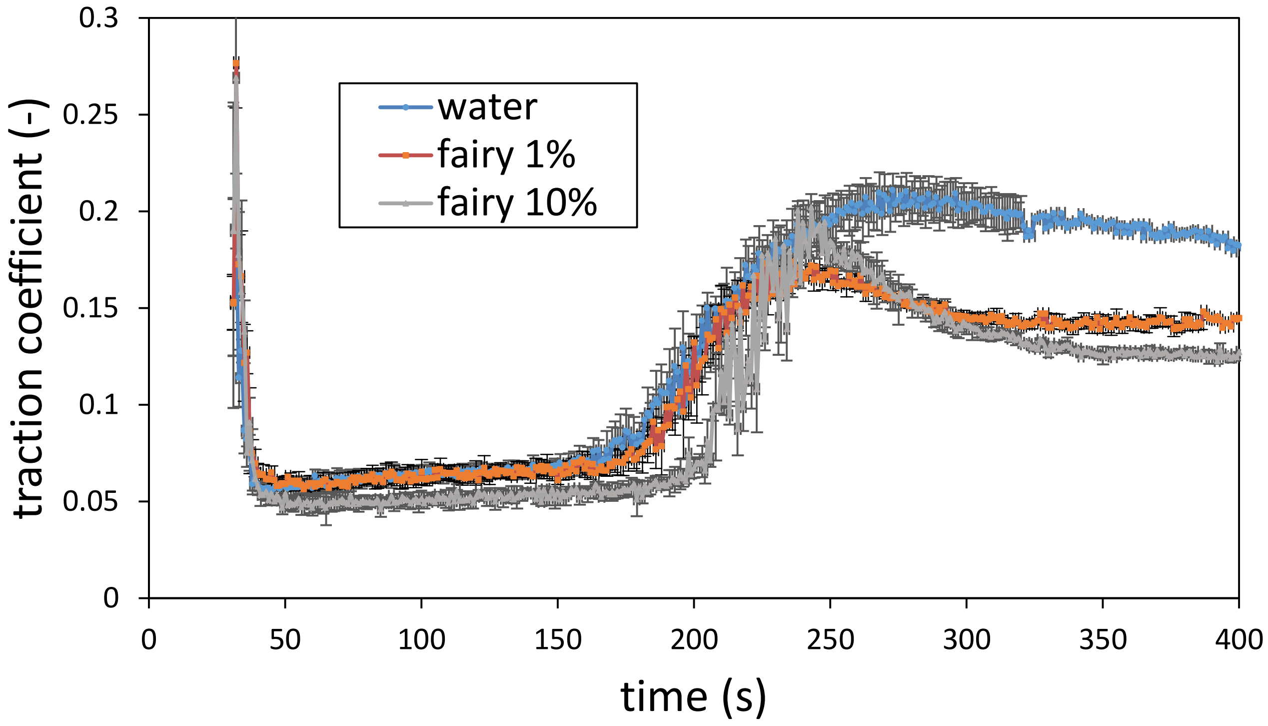


4. Detergent Concentration (2)

1. Water traction coefficient > Fairy traction coefficient values
2. Traction coefficient decreases after the removal of tomato puree

Lubrication effect



Conclusion

Parameters

- Mass: No effect on cleaning rate
- Load, Speed: load/speed increase → earlier traction coefficient increase and better cleaning
- Detergent: Lubrication hinders cleaning efficiency of detergent for the experiment in MTM for tomato puree

FORMULA X

Understand Formulate Innovate

Thank you for your attention