



**2022 MELISSA CONFERENCE**  
8-9-10 NOVEMBER 2022

CREATING  
A CIRCULAR  
**FUTURE**

# Kombucha-derived biomaterials for life in space.

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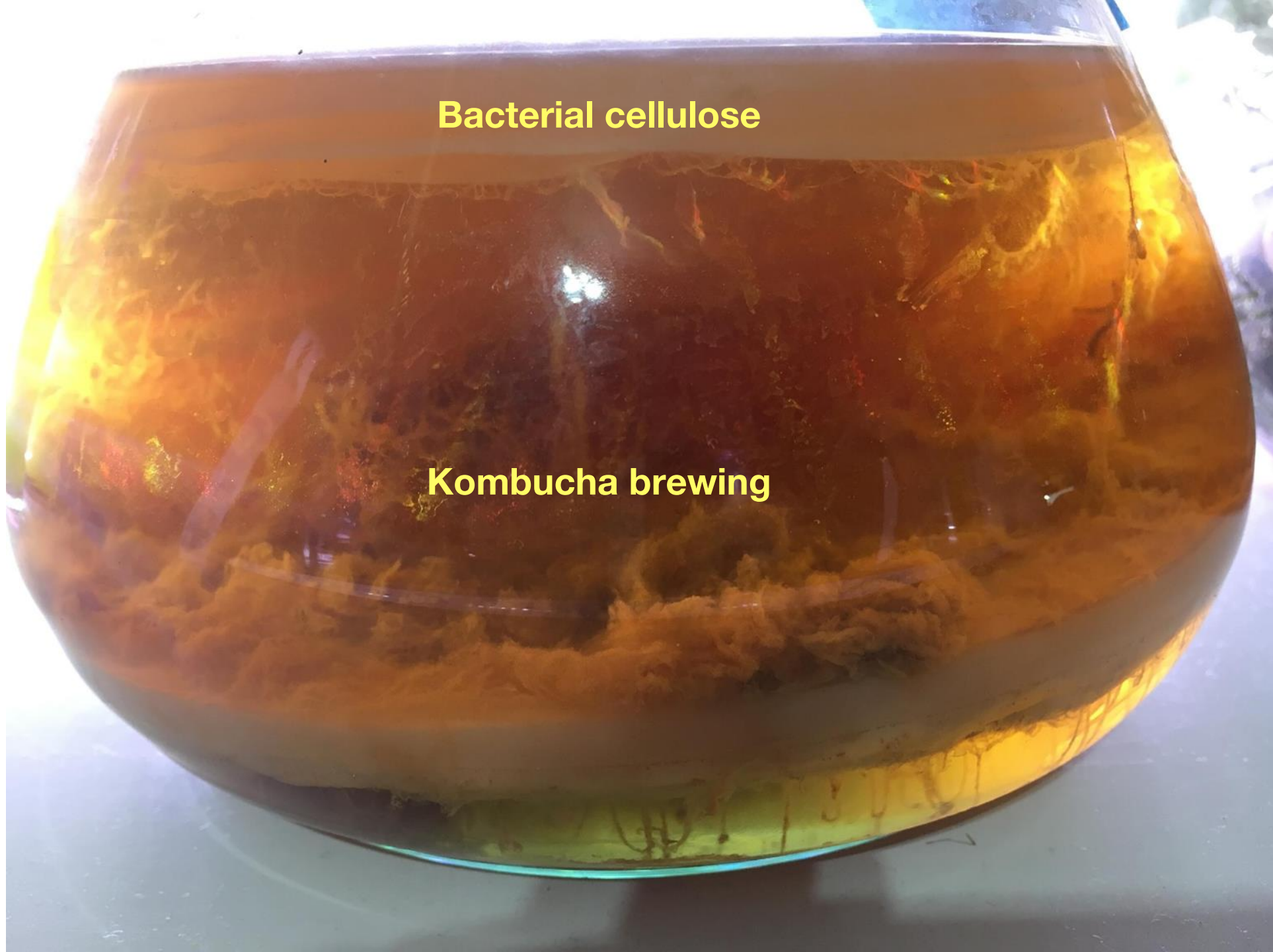


SPACE  
TECHNOLOGY  
CENTRE  
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**Bacterial cellulose**

**Kombucha brewing**





# Comparison of the average values for bacterial and plant cellulose properties

(Wang, et al., 2019)

Properties	Bacterial cellulose	Plant cellulose
Tensile strength, MPa	20-300	25-200
Water holding capacity, %	>95	25-35
Crystallinity, %	74-96	40-85
Purity, %	>99	<80
Degree of polymerization	14000-16000	300-10000
Porosity, %	>85	<75



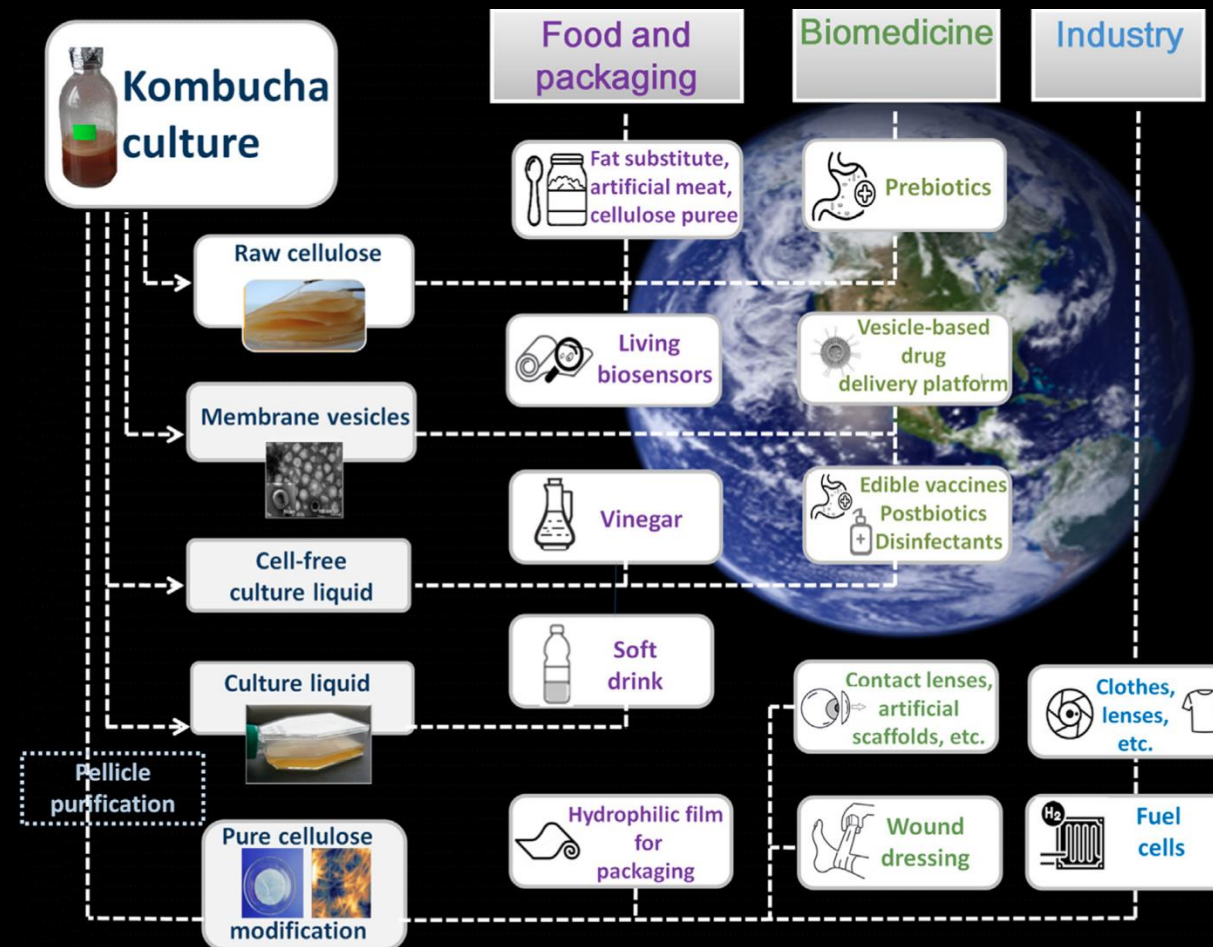
# Cellulose-producing bacteria and structure of the obtained cellulose (Wang et al., 2019)

<b>Bacterial genus</b>	<b>Structure of cellulose</b>
<i>Acetobacter/ Komagataeibacter</i>	Fibril structure/ Ribbon structure
<i>Achromabacter</i>	Ribbon structure
<i>Agrobacterium</i>	Fibril structure
<i>Aerobacter</i>	Fibril structure
<i>Alcaligenes</i>	Fibril structure
<i>Pseudomonas</i>	Amorphous
<i>Rhizobium</i>	Fibril structure
<i>Sarcina</i>	Not defined

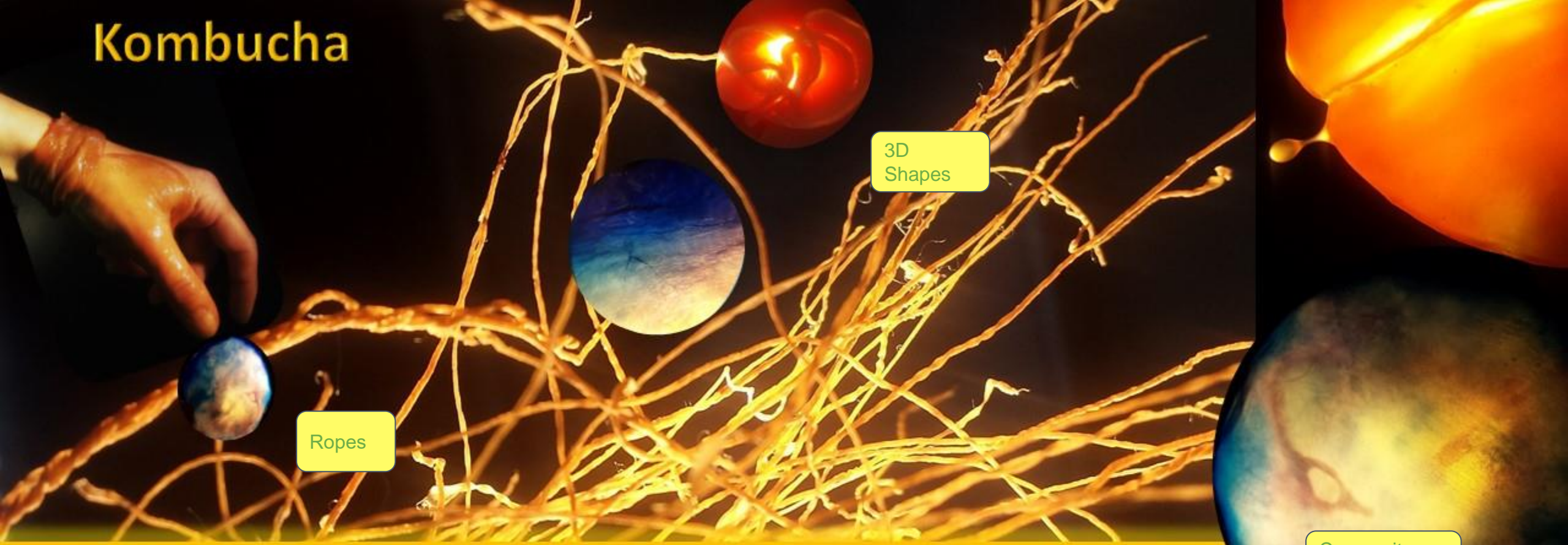


# Kombucha's cellulose-based pellicle as a three-dimensional hub for microbial community-member cells and raw material for fermented food and consumer goods fabrication.

Background image credits: ESA. Kozyrovska et al. 2021. To other planets with upgraded millennial kombucha in rhythms of sustainability and health support. *Frontiers in Astronomy and Space Sciences*. Review.

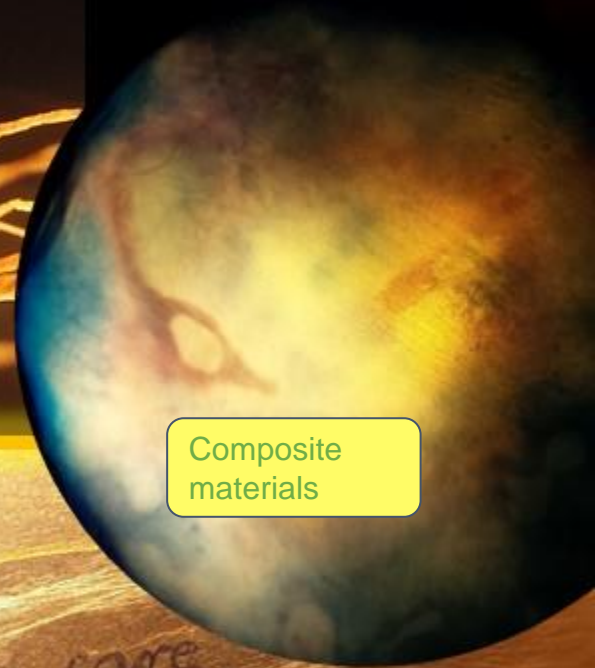


# Kombucha



Ropes

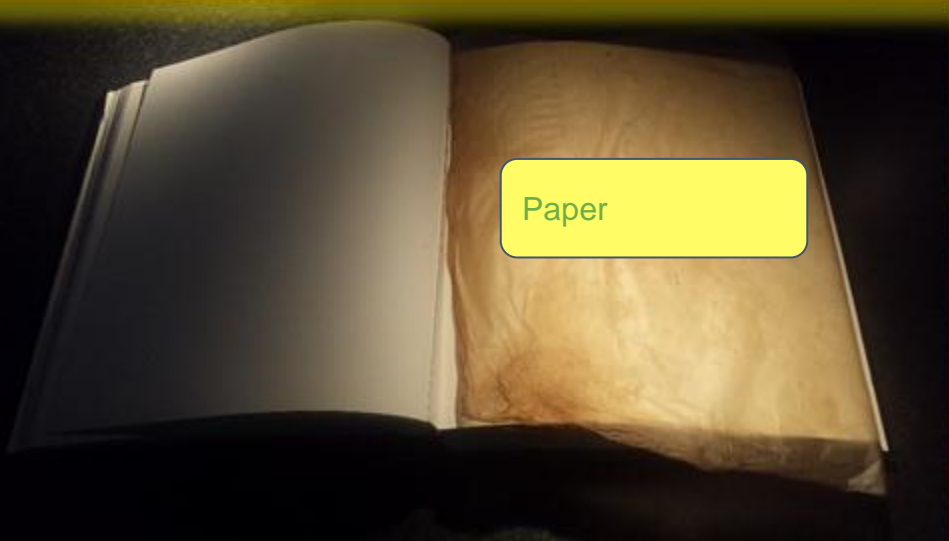
3D  
Shapes



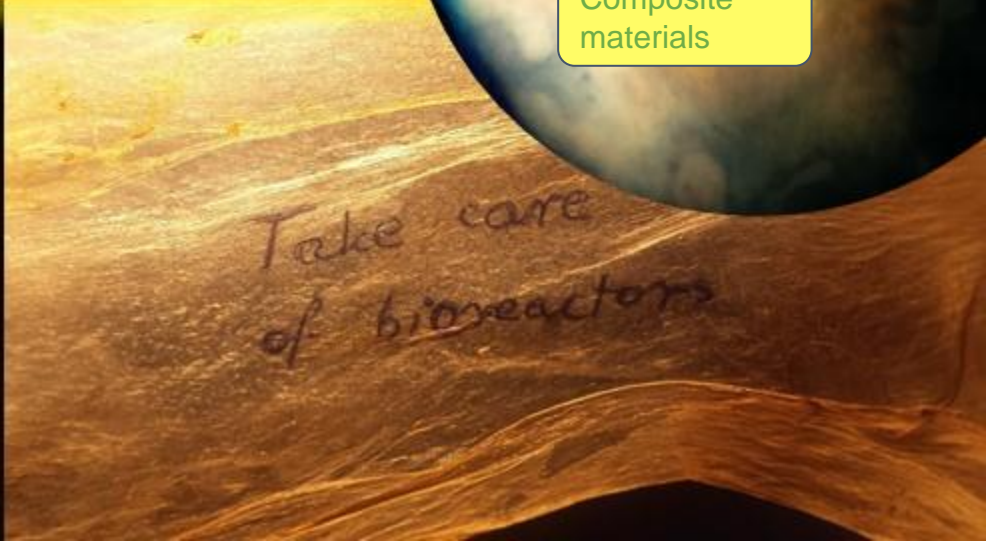
Composite  
materials



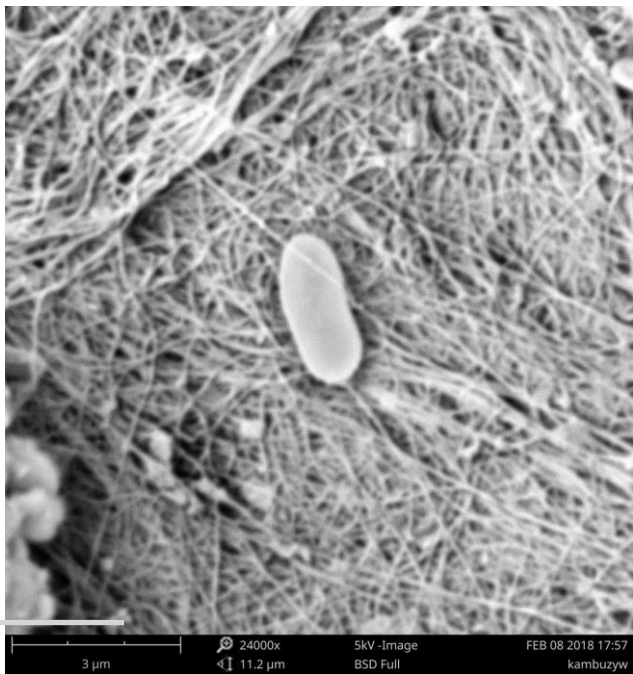
Packaging



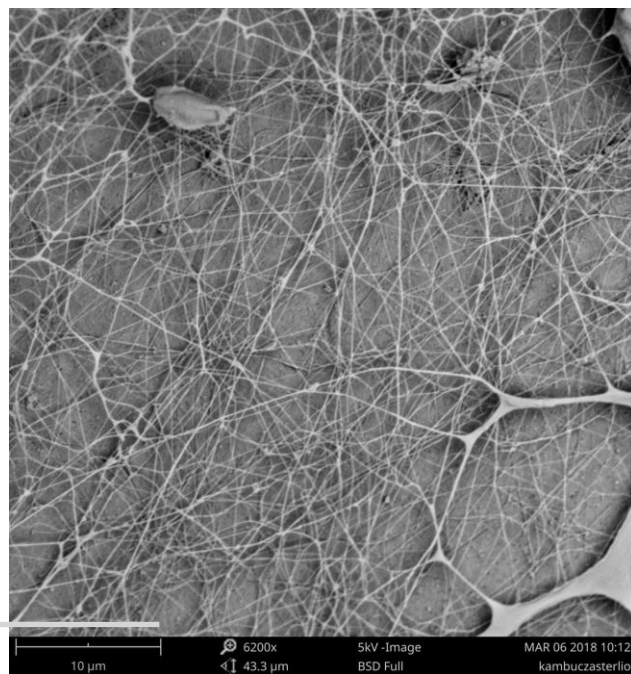
Paper



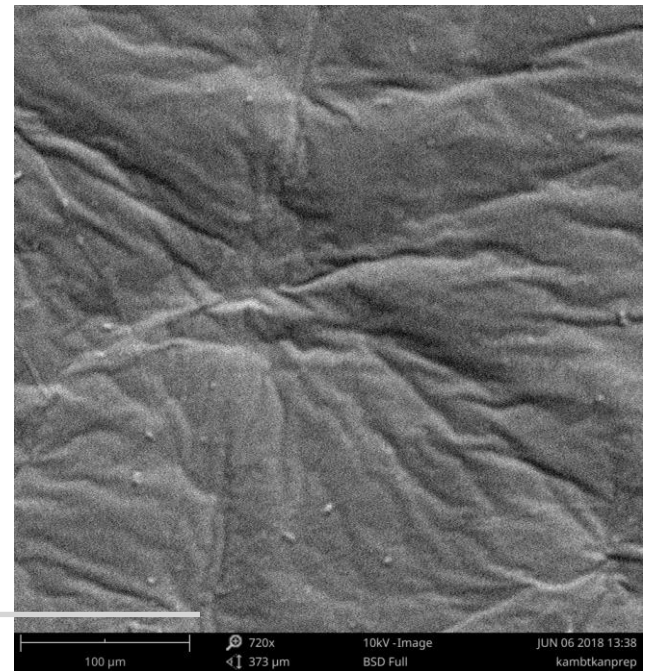
Take care  
of bioreactors



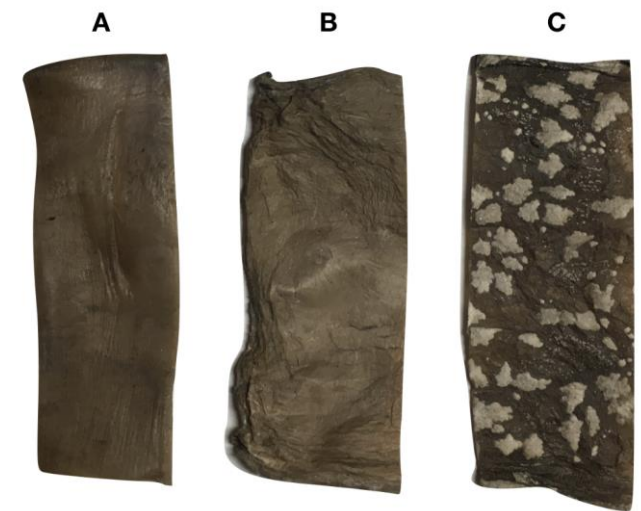
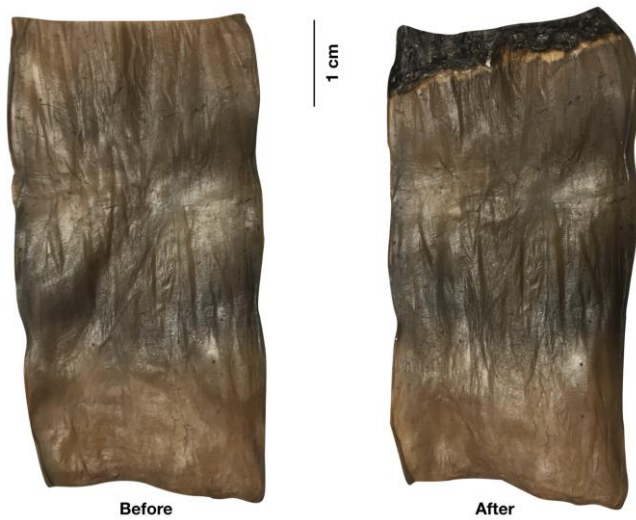
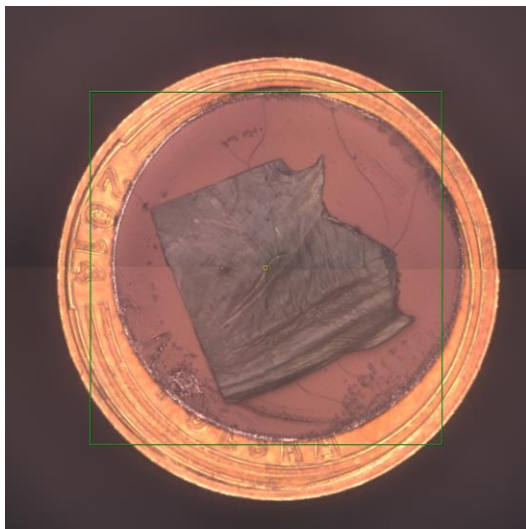
**raw**

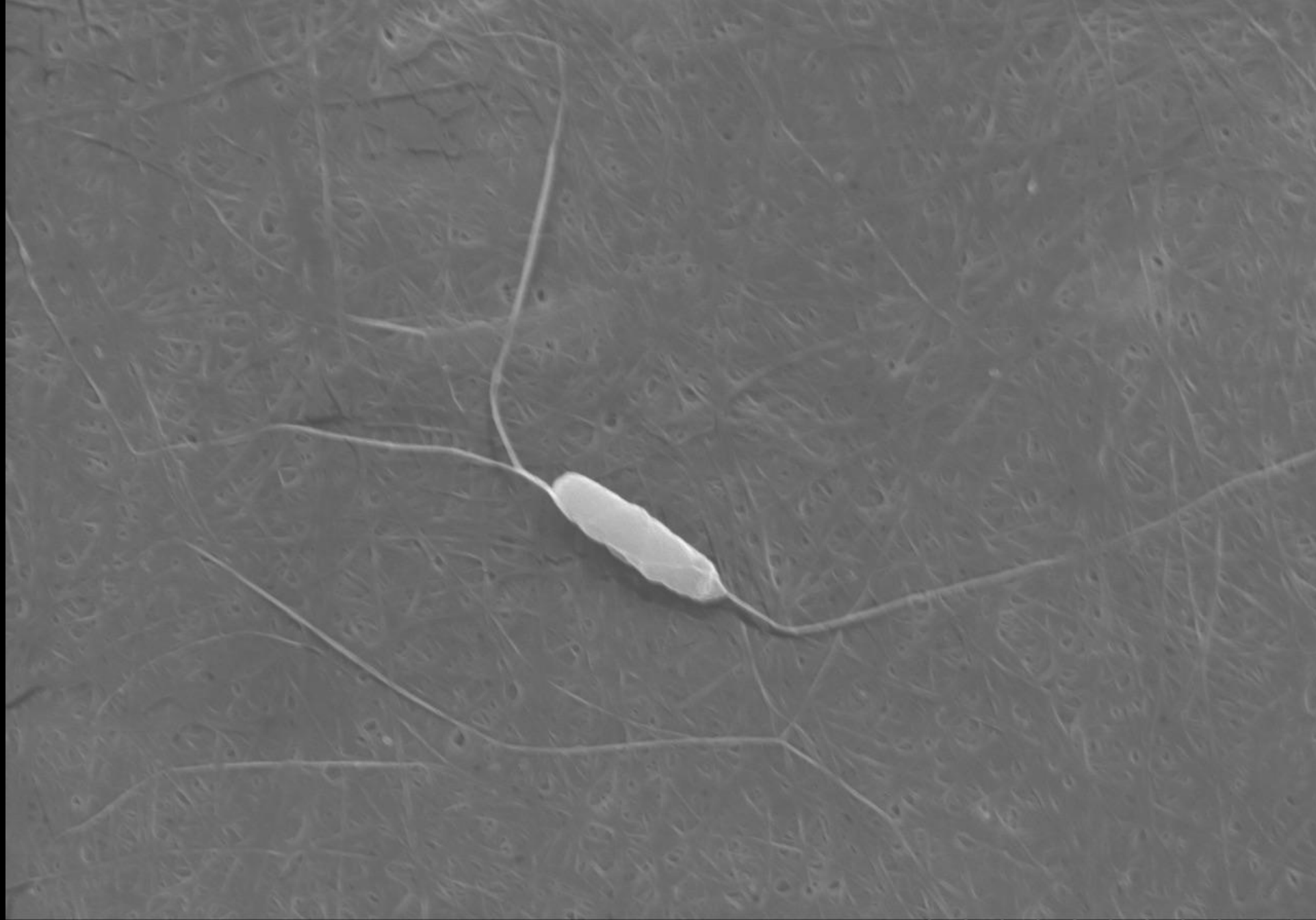


**lyophilised**



**coated**

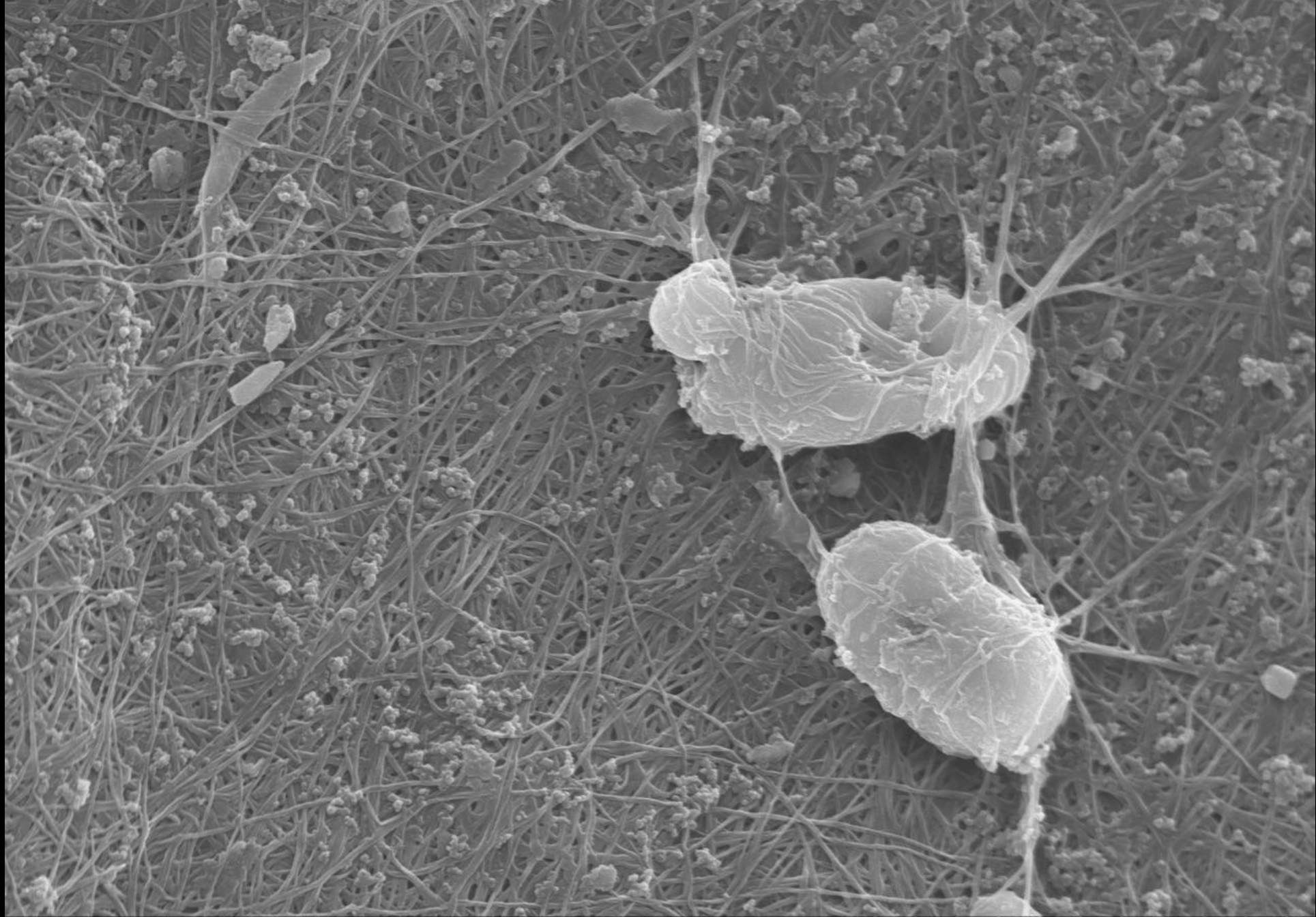




KombY-08 10.0kV 11.1mm x7.00k SE(M)

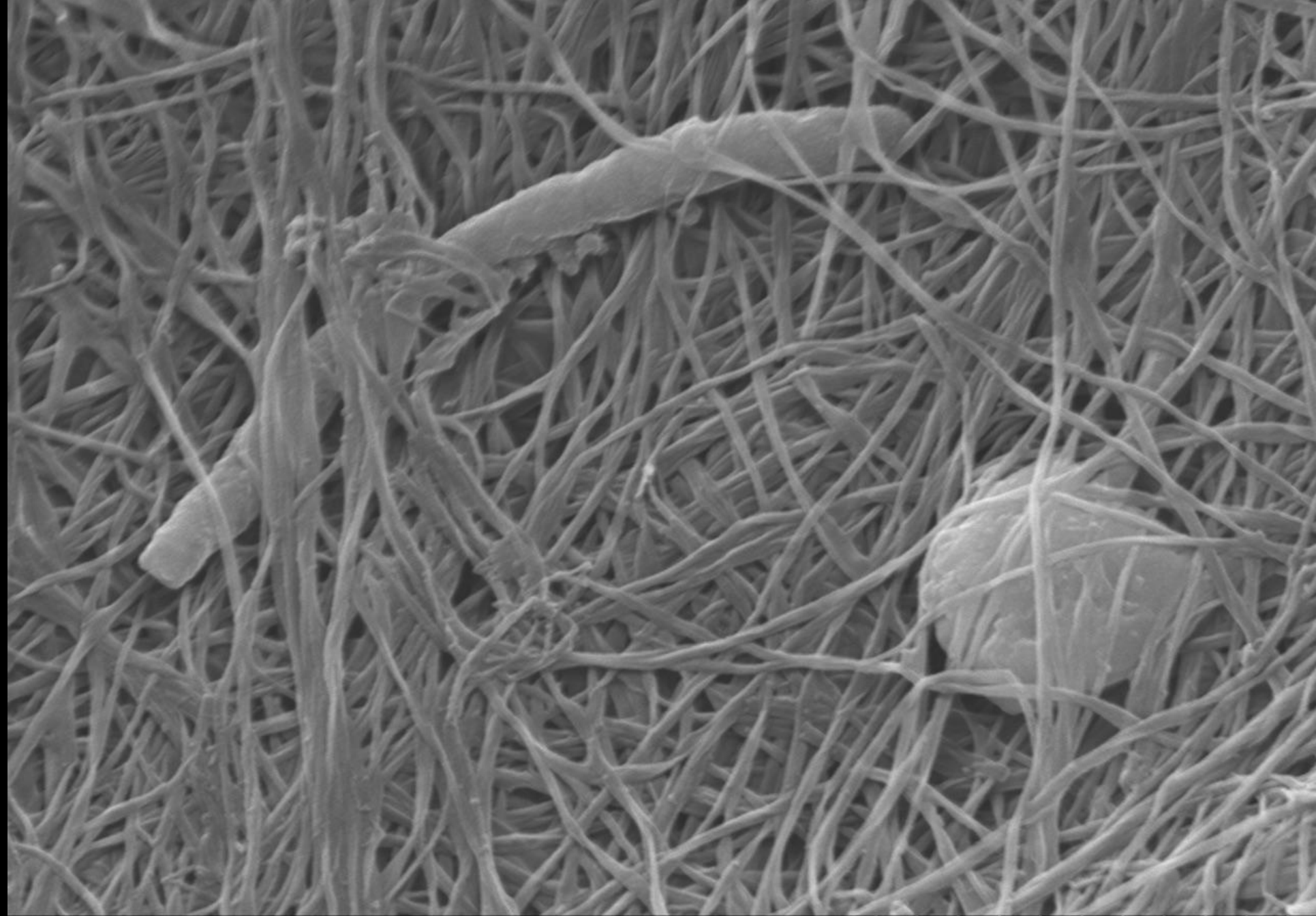
5.00um





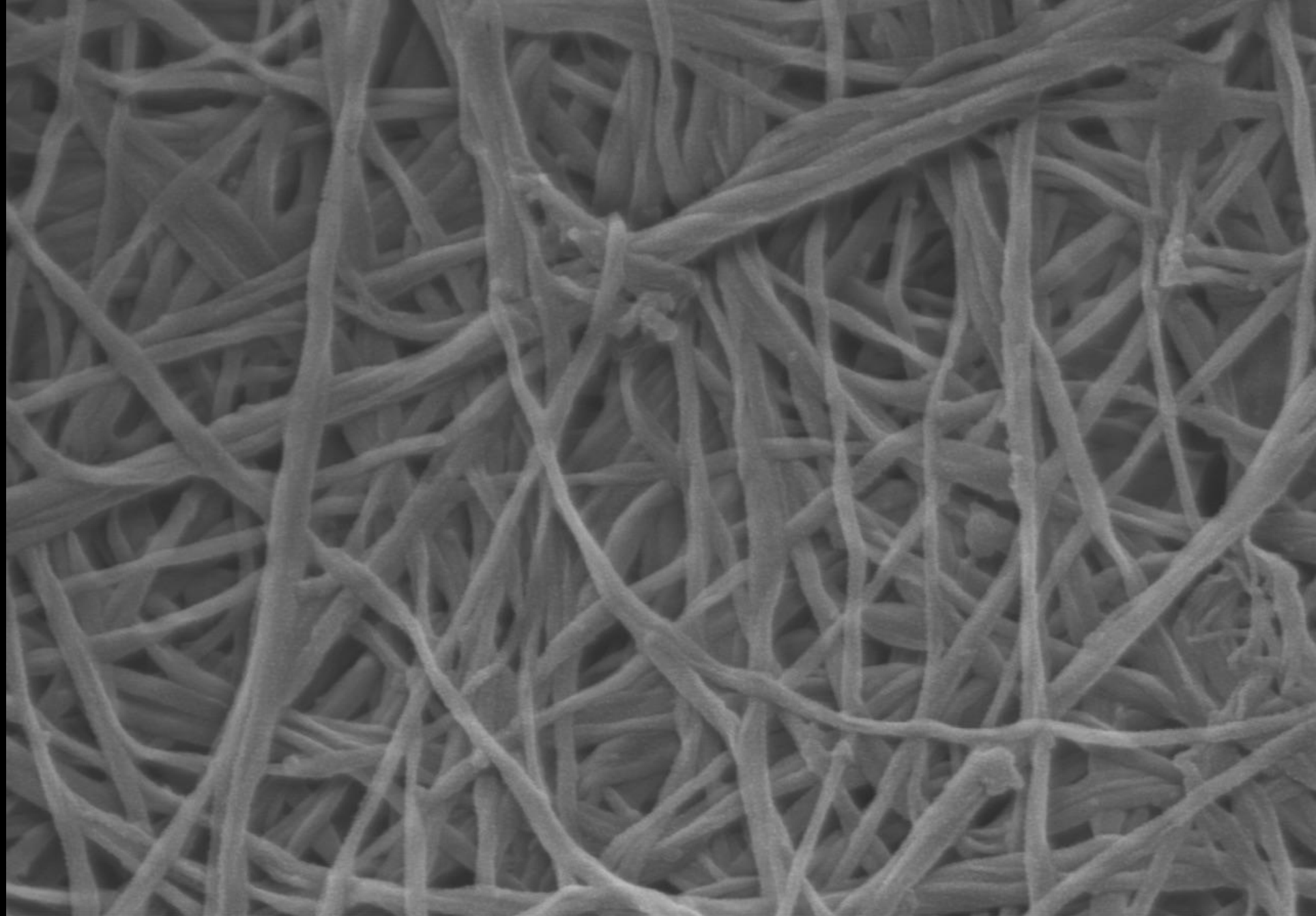
KombX-13 10.0kV 11.3mm x8.00k SE(M)

5.00um



KombX-07 10.0kV 11.3mm x20.0k SE(M)

2.00um



KombX-05 10.0kV 11.3mm x40.0k SE(M)

1.00um



**A**

2.5 cm

**B****C**



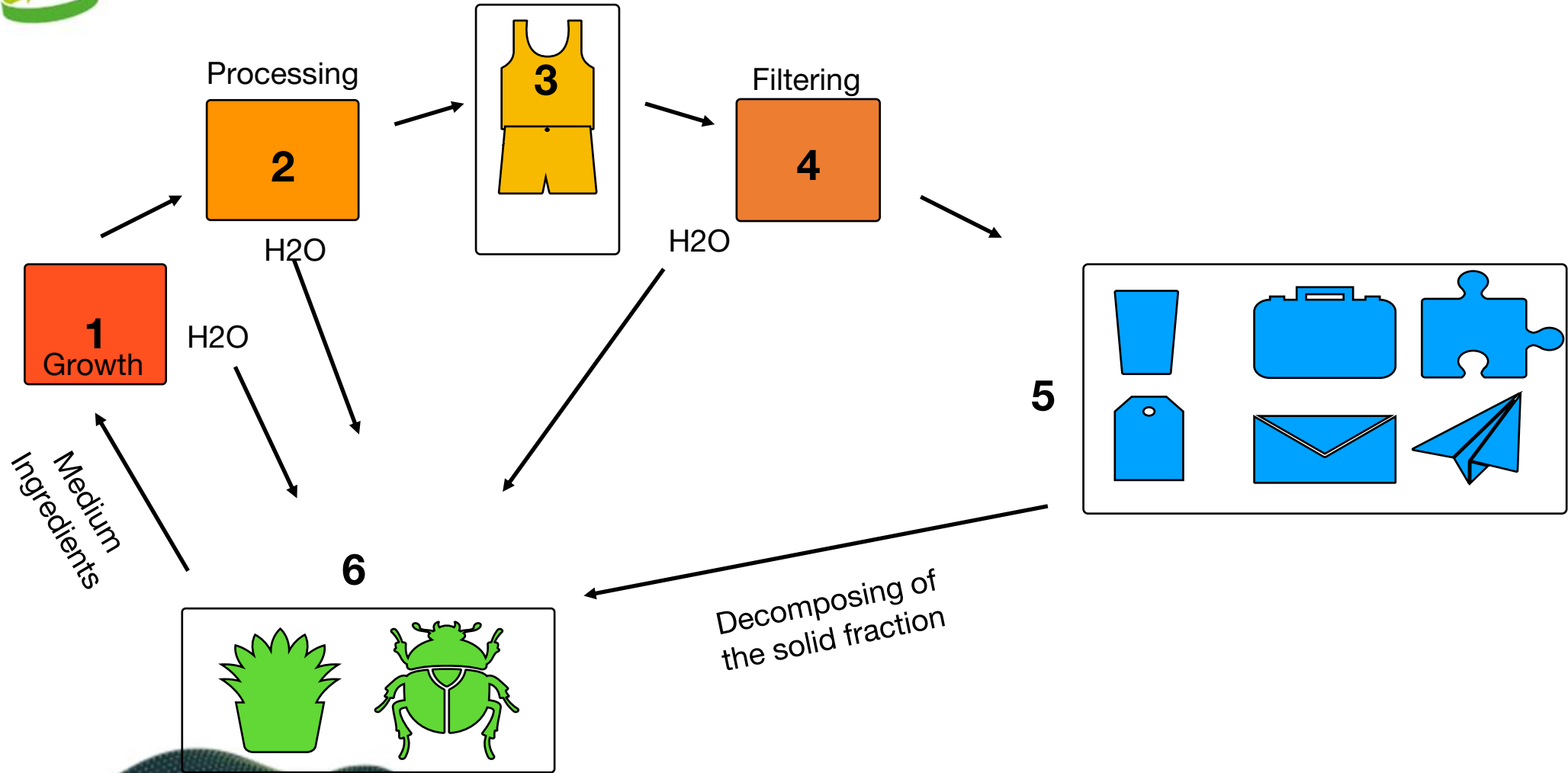
# Clothes in space - demonstration and testing in analog environment





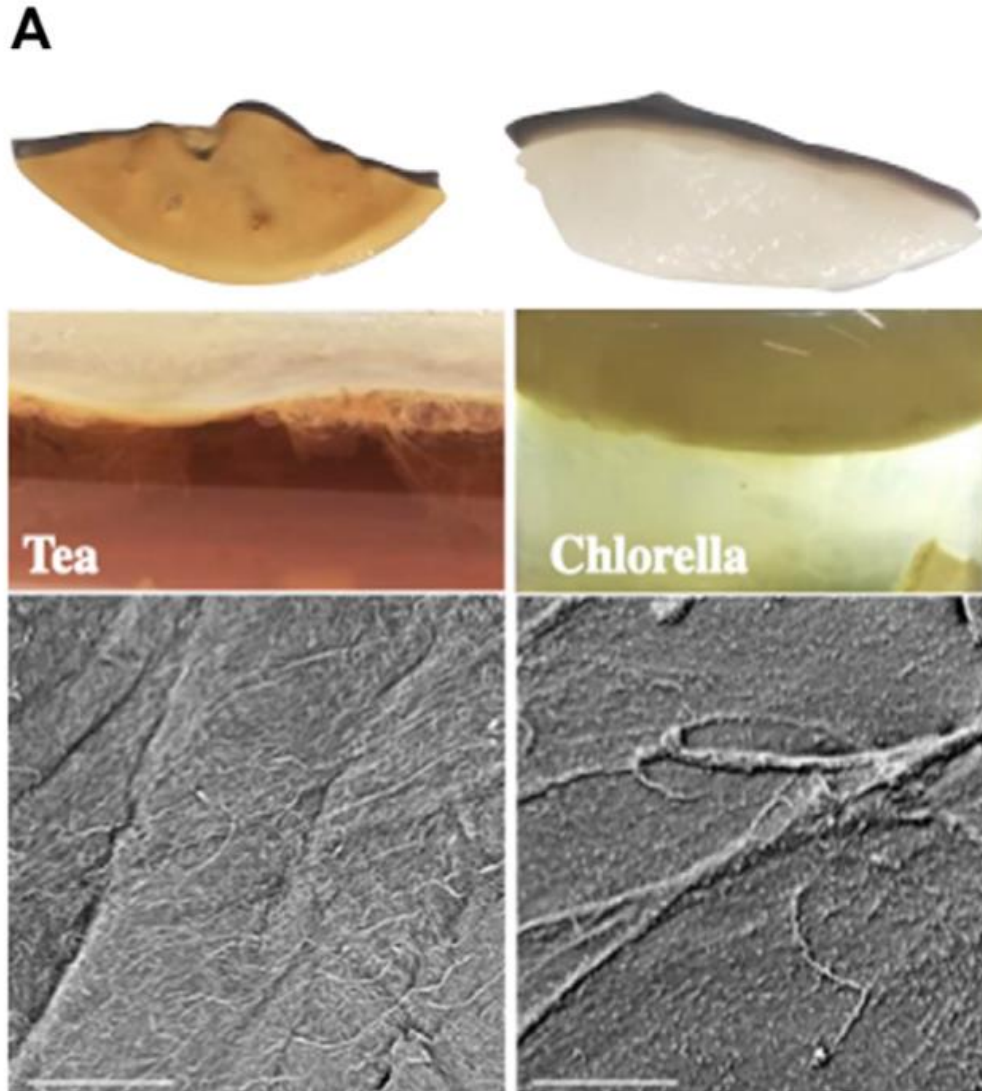


# Kombucha cycle in isolated space - concept



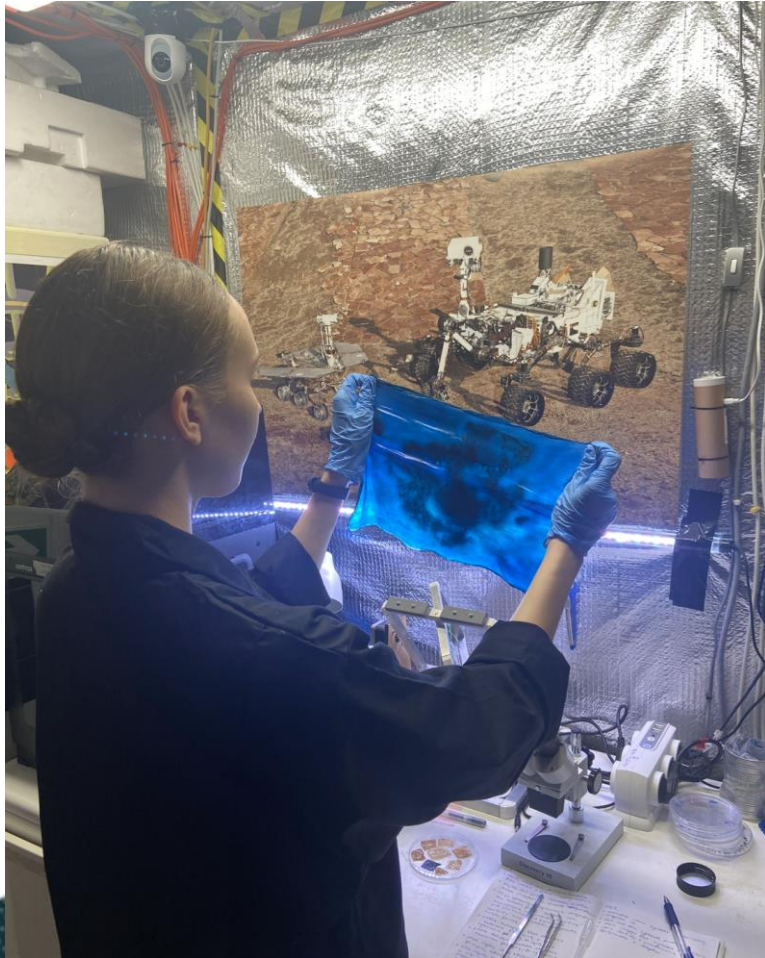


**Bacterial nanocellulose can be used for clothes in space.** (A) The traditional substrate for KMC, a tea, must be replaced by alternative components, e.g., photosynthetic algae, for biofabrication of cellulose. (B) KMC's material absorbs odours. It can be easily cleaned and sterilised. It folds gently to very compact volumes. Folding does not implicate changes in structure of the material. Kombucha's cellulose does not generate allergic responses in direct contact with human skin. It makes skin softer and visibly healthier (Kołodziejczyk, 2018; Kamiński et al., 2020).





# Student projects with kombucha during analog lunar missions - 1 week isolation





Kombucha  
THERAPY

Kombucha  
THERAPY  
Mask  
Ingredients:  
Pure kombucha, natural collagen,  
Life Water and botanicals.  
Application:  
For mask use have the skin clean, apply the mask evenly.  
Storage:  
Keep at Room Temperature in the dark.

Kombucha  
THERAPY

Kombucha  
THERAPY



# Optimisation of 3D printing from lunar regolith and cellulose.

- (A) KMC with lunar regolith simulant,
- (B) KMC with pure cellulose

Planetary and Space Science 99 (2014) 70–83

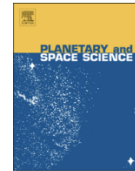


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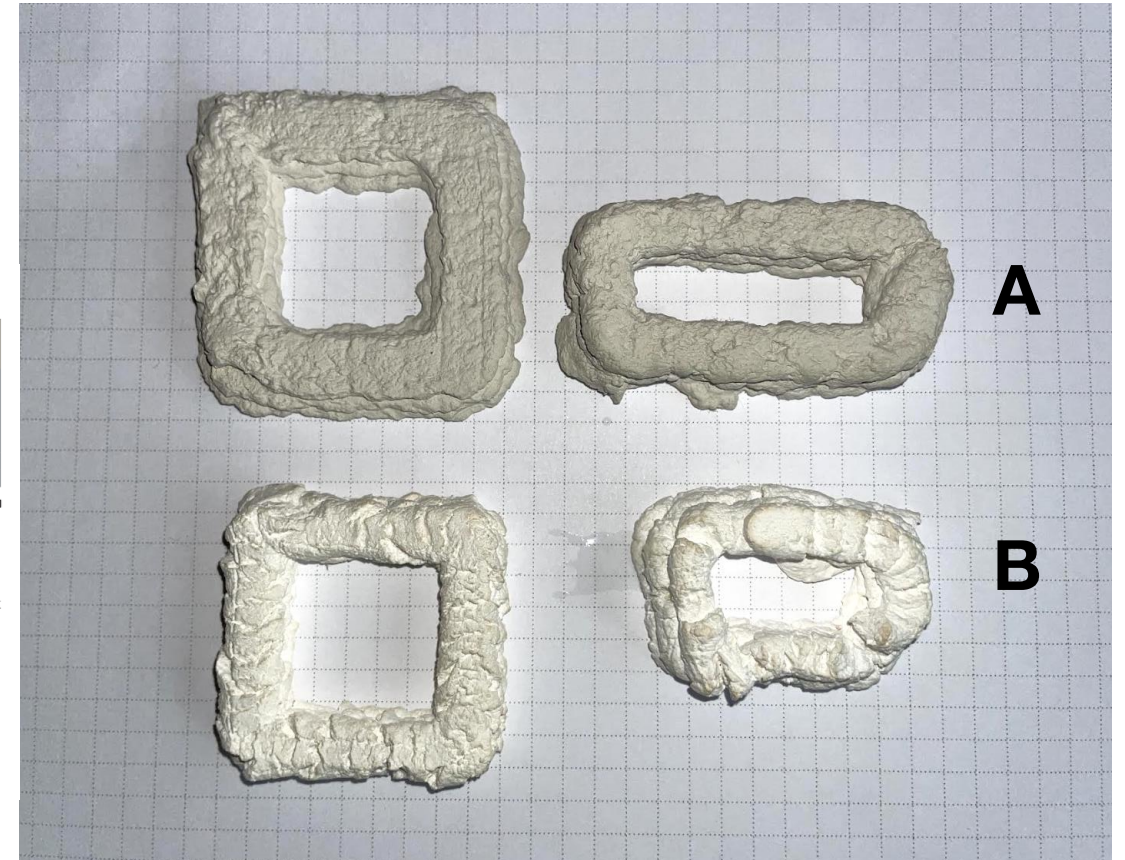
Determining the geotechnical properties of planetary regolith using Low Velocity Penetrometers



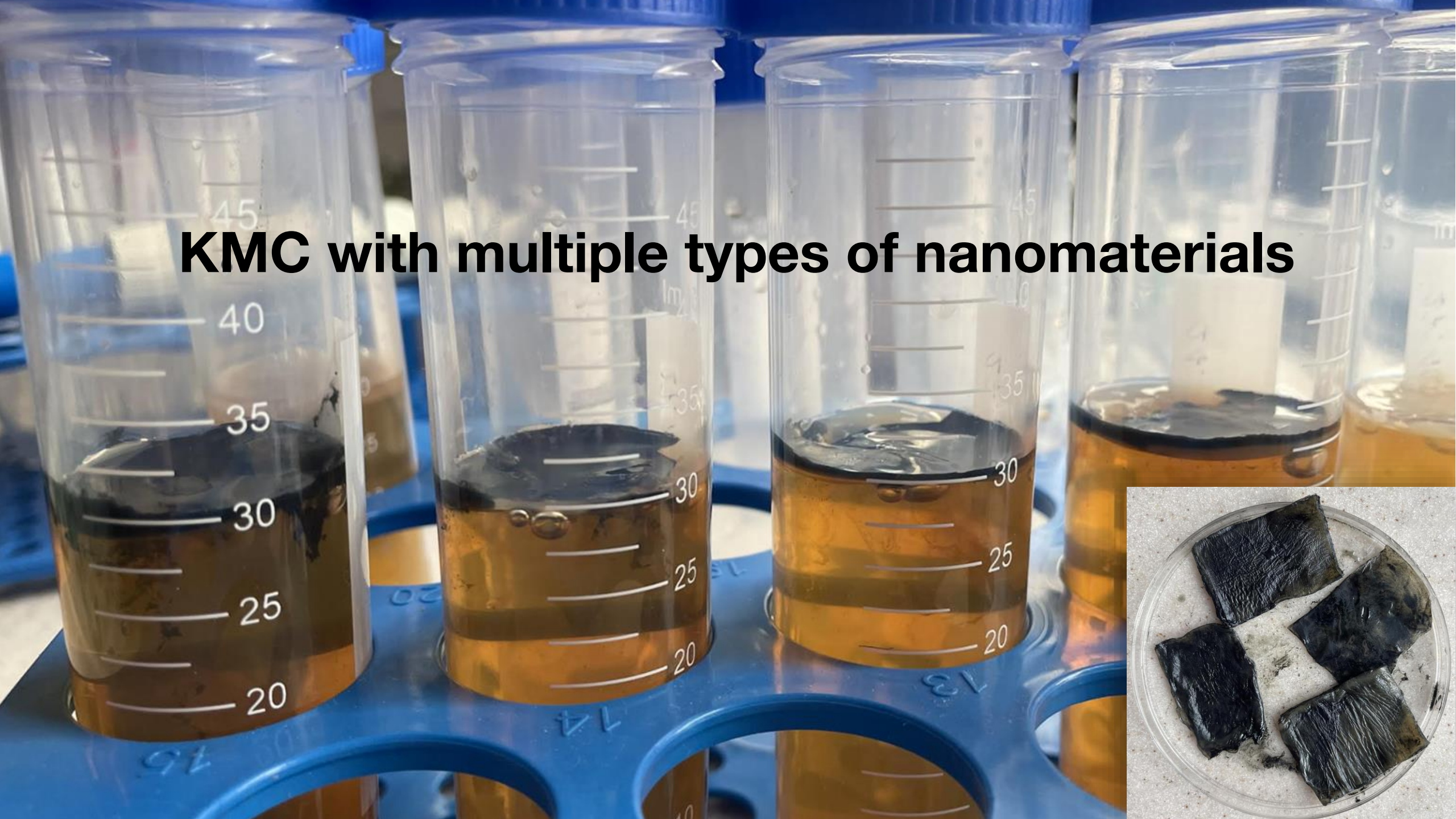
K. Seweryn<sup>a,\*</sup>, K. Skocki<sup>a</sup>, M. Banaszkiwicz<sup>a</sup>, J. Grygorczuk<sup>a</sup>, M. Kolano<sup>b</sup>, T. Kuciński<sup>a</sup>, J. Mazurek<sup>b</sup>, M. Morawski<sup>a</sup>, A. Białek<sup>a</sup>, H. Rickman<sup>a</sup>, R. Wawrzaszek<sup>a</sup>

<sup>a</sup> Space Research Centre of the Polish Academy of Sciences, 18a Bartycka street, 00-716 Warsaw, Poland

<sup>b</sup> AGH University of Science and Technology, Faculty of Mining and Geoengineering, 30 Mickiewicza Avenue, 30-059 Krakow, Poland



# KMC with multiple types of nanomaterials





BASALT



0.5 -1 mm 10%



1 -3 mm 10%



3 -6 mm 10%



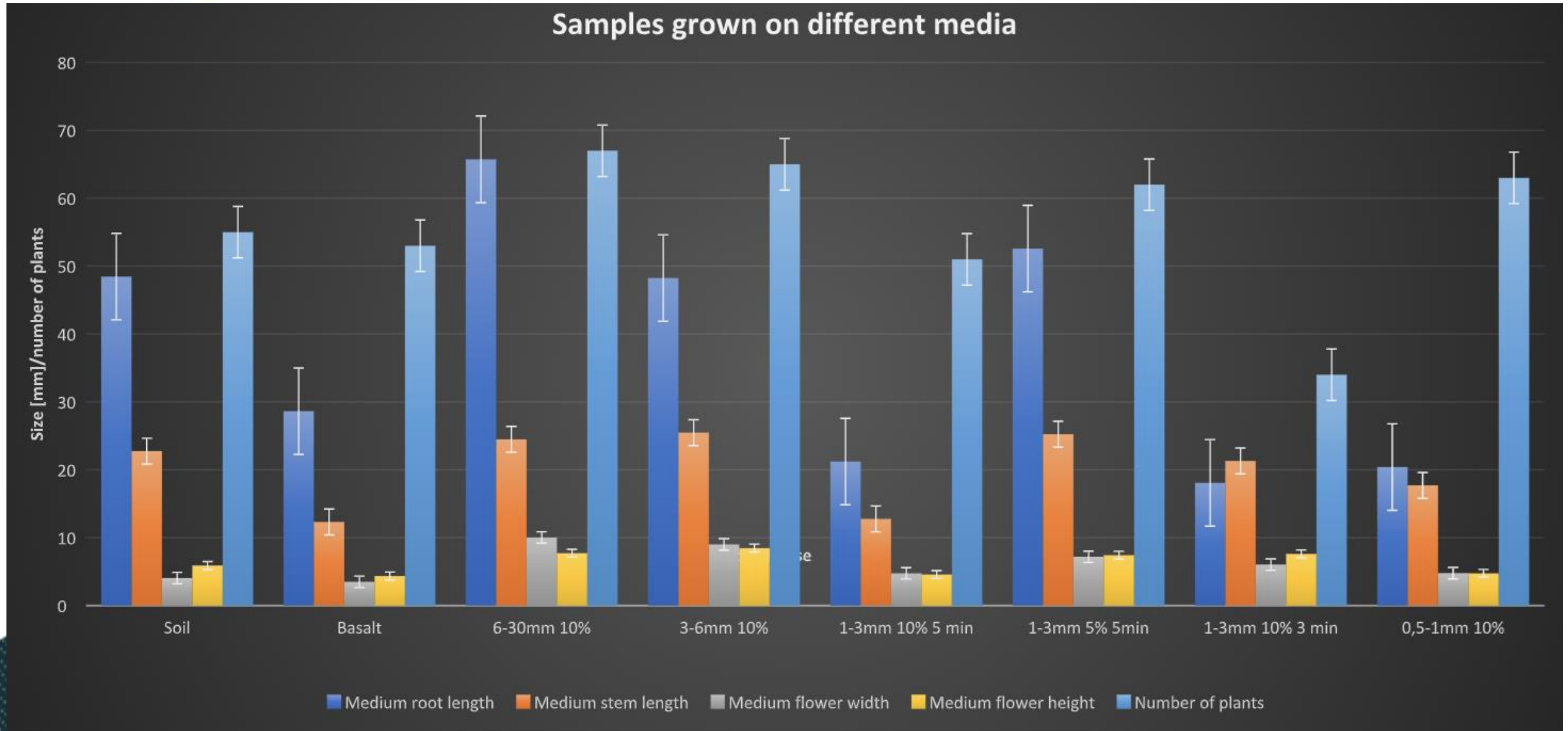
6 -30 mm 10%



garden soil

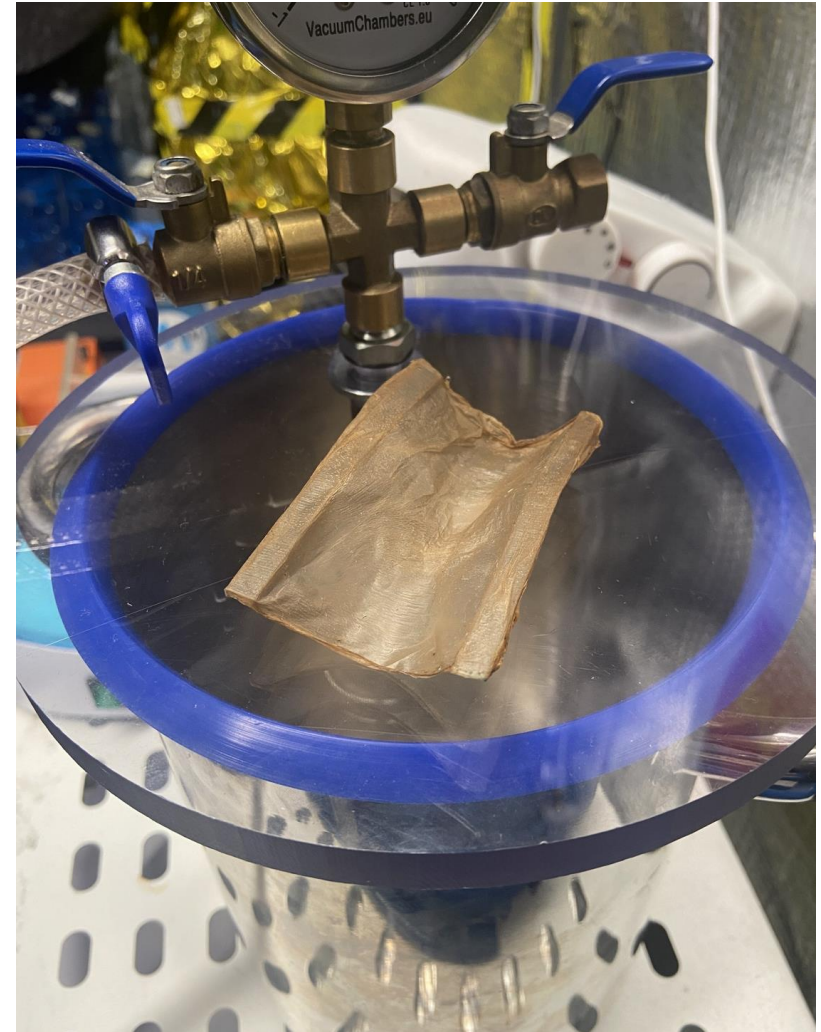
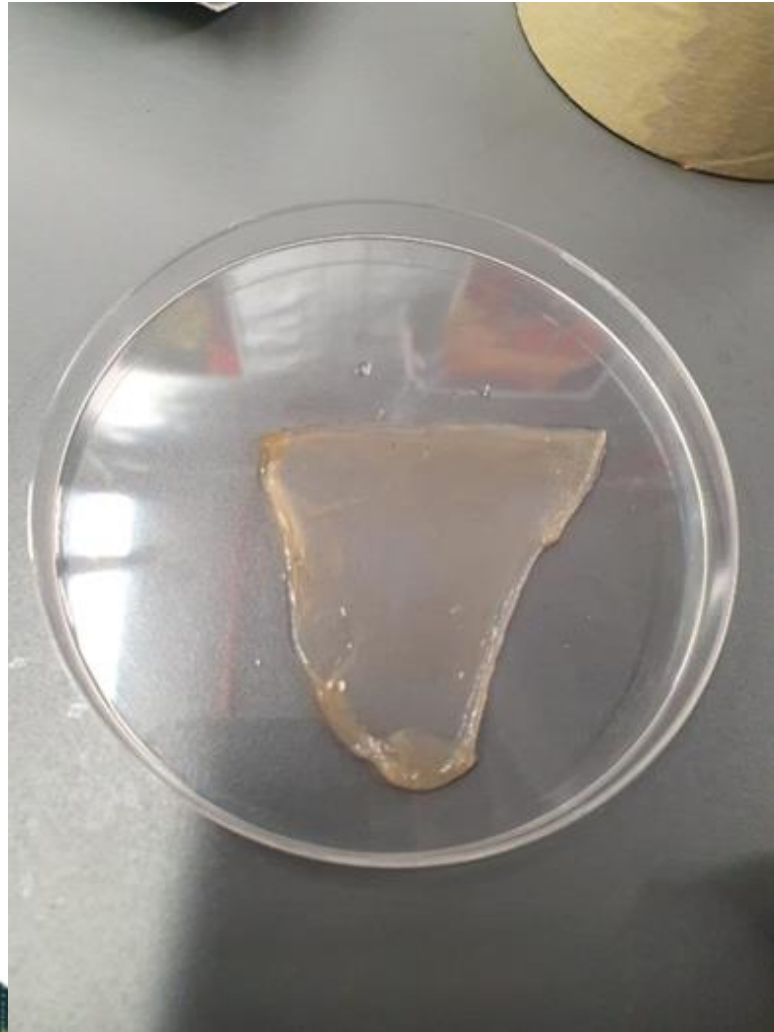
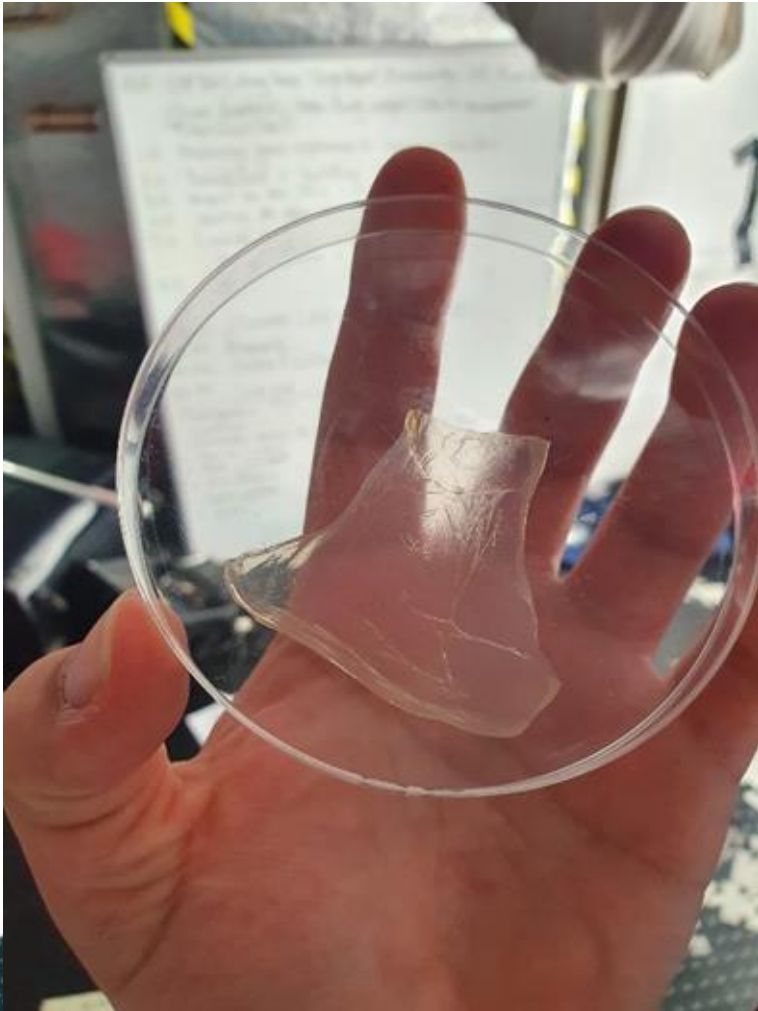


# Cress growth on the kombucha-derived media.





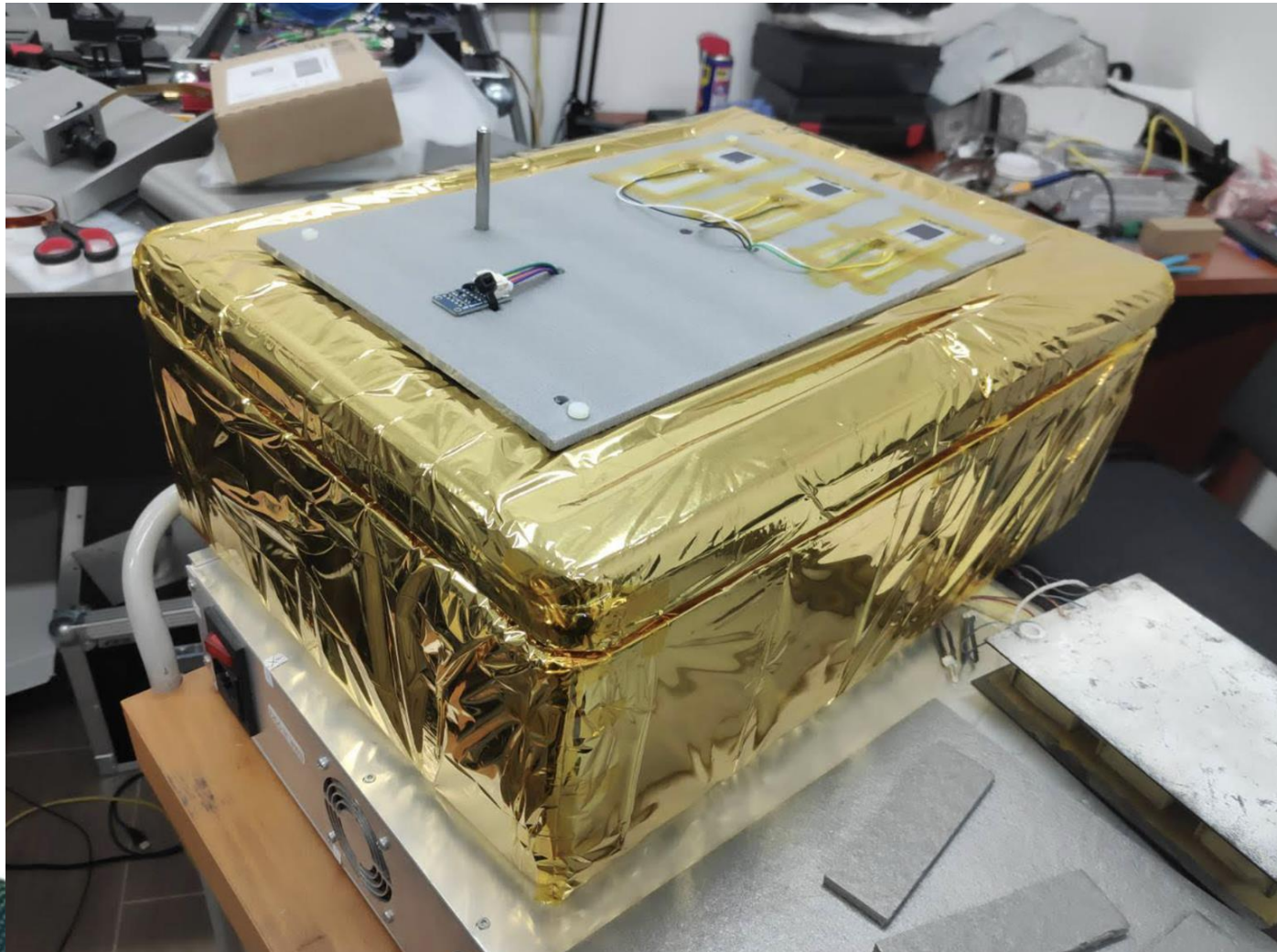
# Kombucha's cellulose outgassing







# Experiments in the stratosphere





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**THANK YOU.**

**Agata Kołodziejczyk**

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