Enzymatic degradation and pilot-scale composting of cellulose-based films with different chemical structures

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Global production of fossil-based plastics is almost 350 million tons per year

8.3 million microplastic particles in every cubic meter of water

Solutions from cellulose-based materials

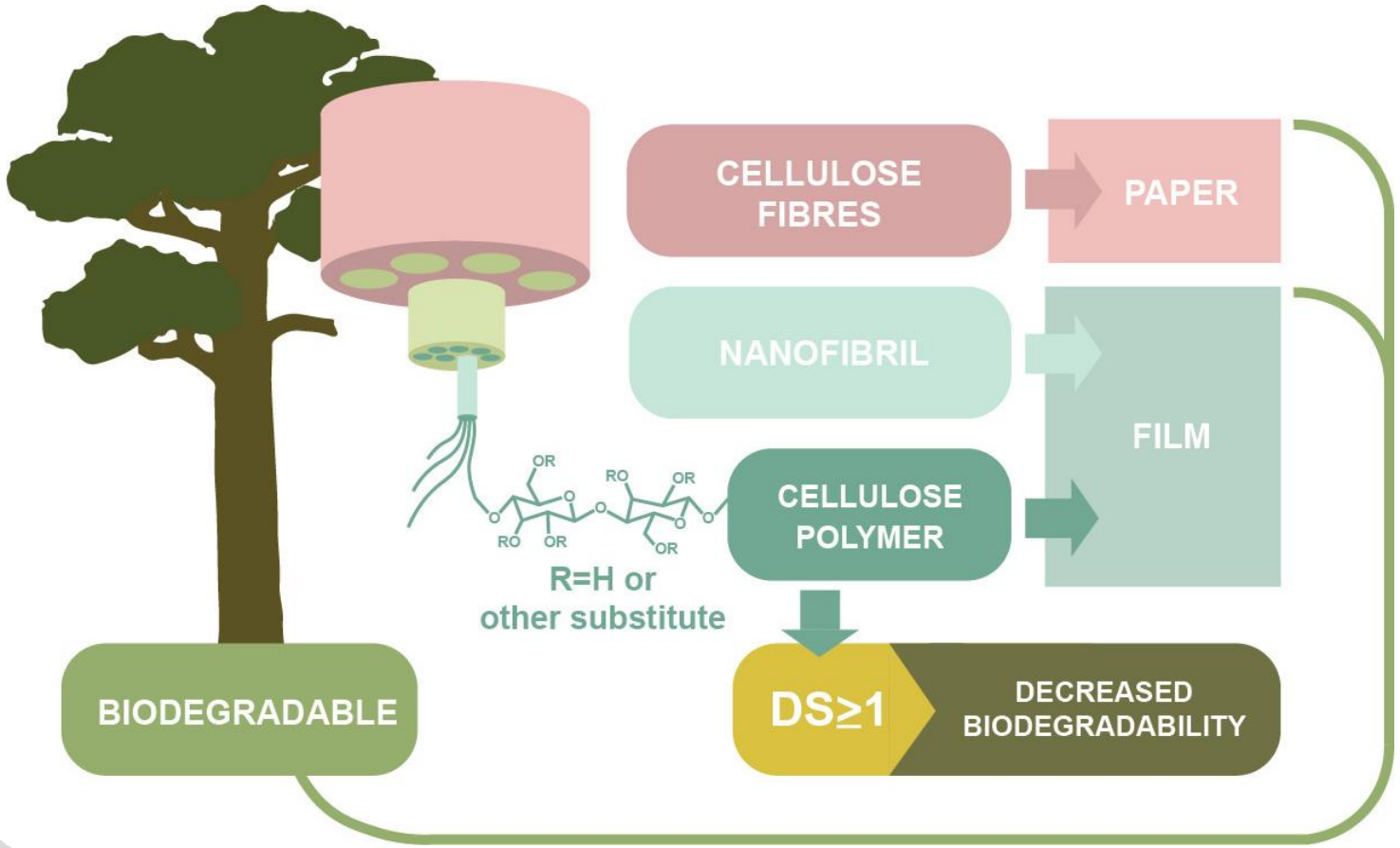
WHY
cellulose

HOW
to manufacture and study degradation

WHAT
results were obtained


Abundant
Renewable
Biocompatible
Biodegradable
High stiffness
Tunable structure
Photo: VTT Technical Research Centre of Finland Ltd

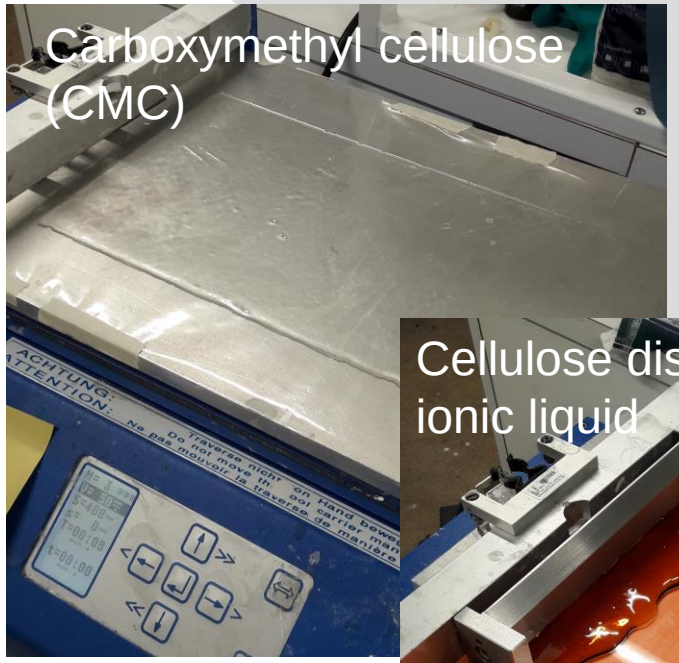
Approach

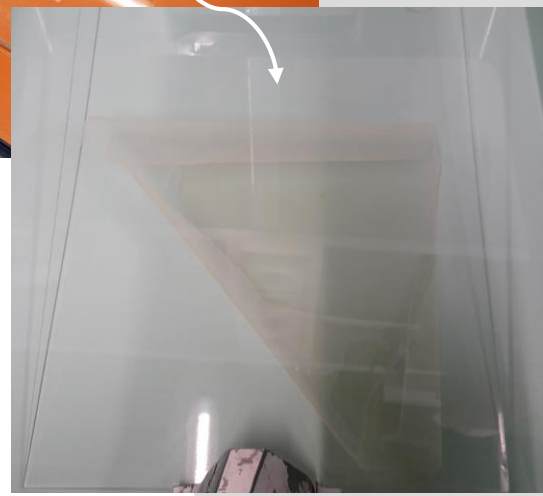


- Chemical characterization (FTIR)
- Microscopy
- **Mechanical properties**
- Optical properties
- **Enzymatic degradation**
- **Pilot-scale composting**

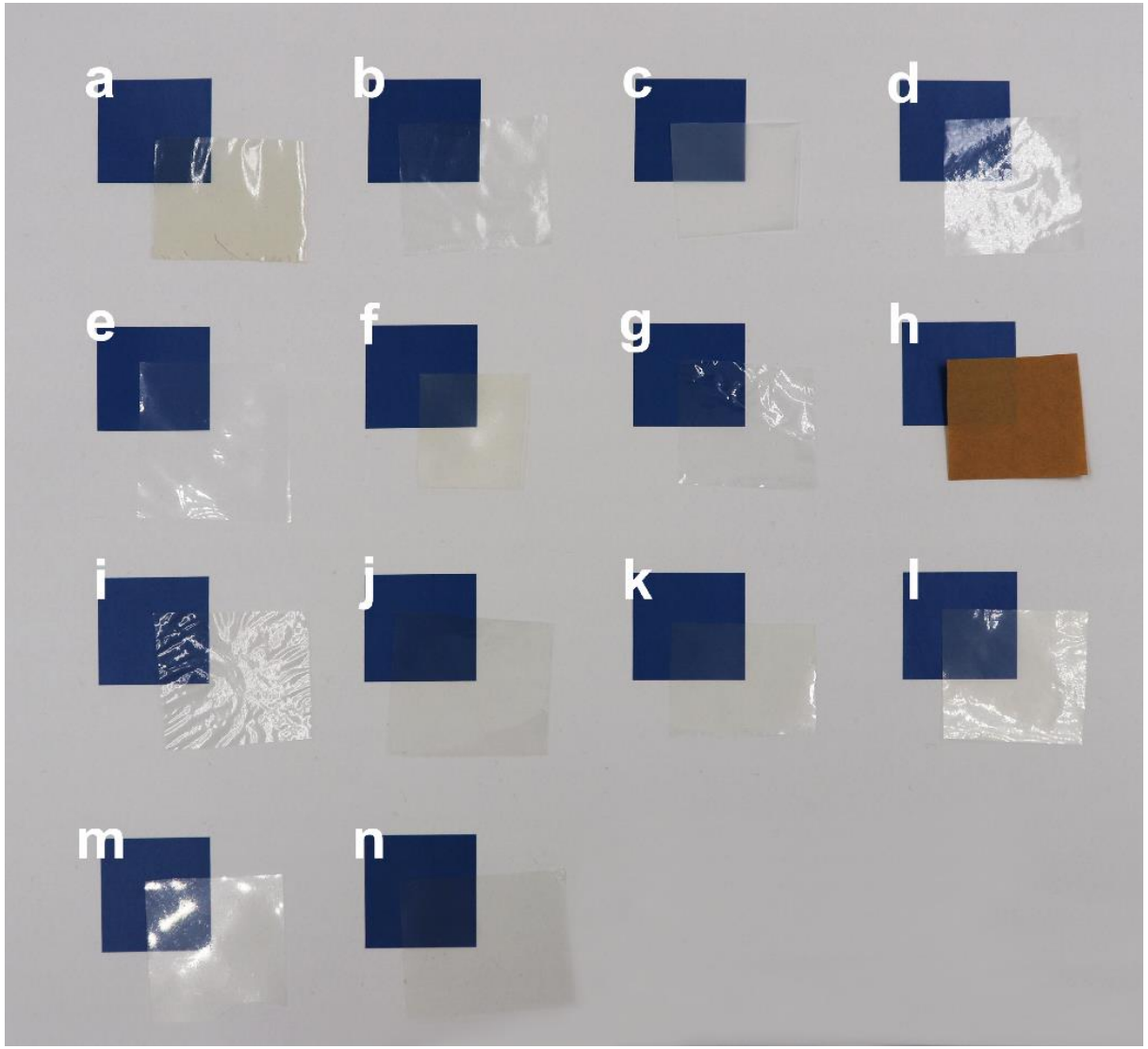
Film manufacturing

- Films were prepared by solvent casting method using an electromotive film applicator device
- Some films regenerated after casting
- All films dried in room temperature



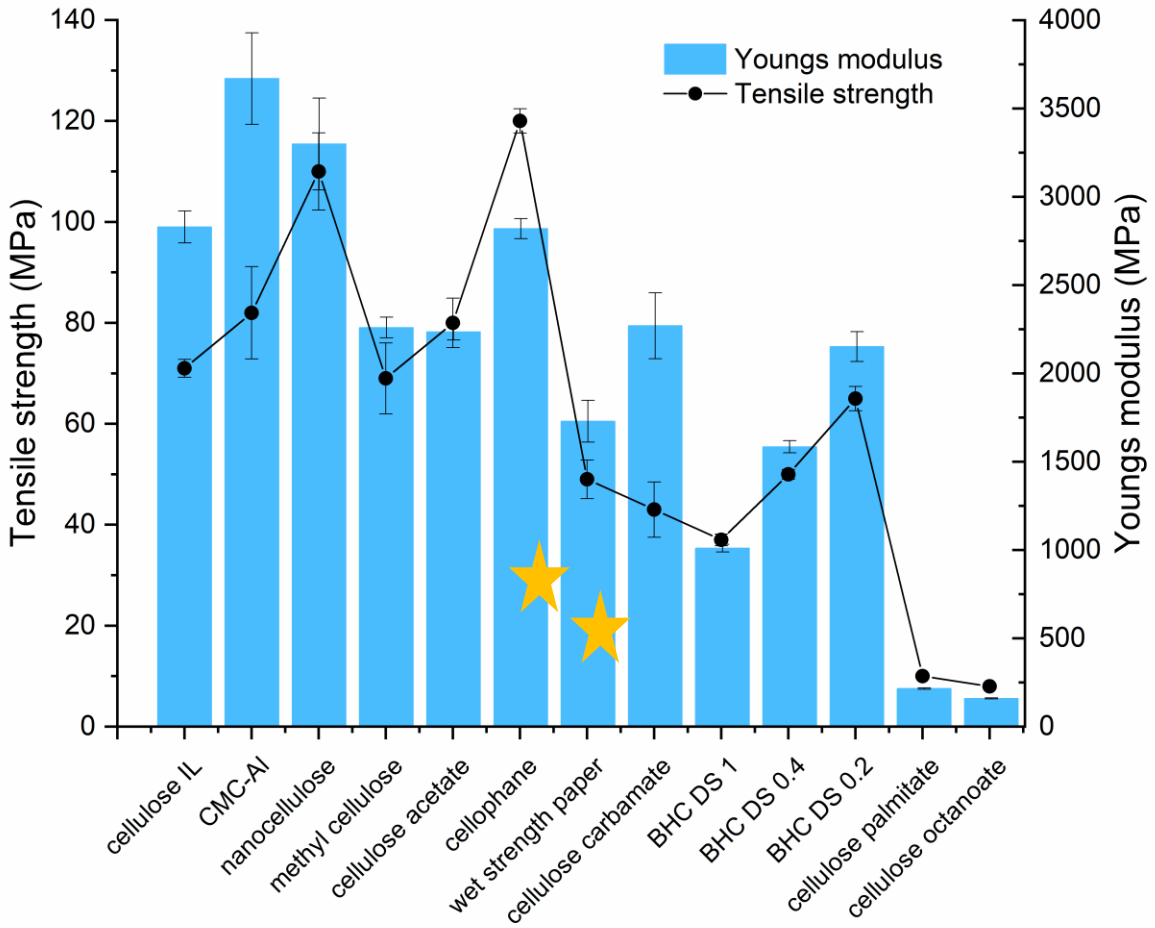


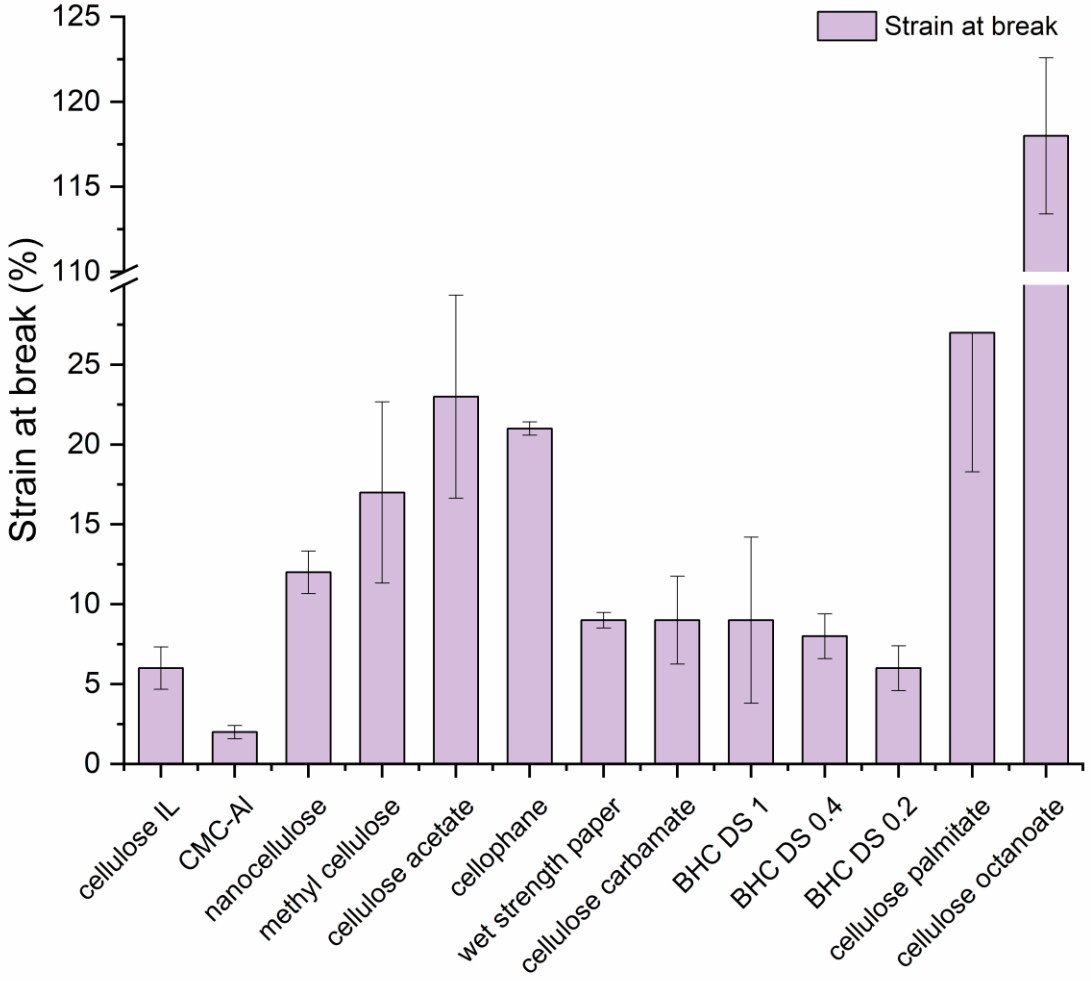
Cellulose-based films



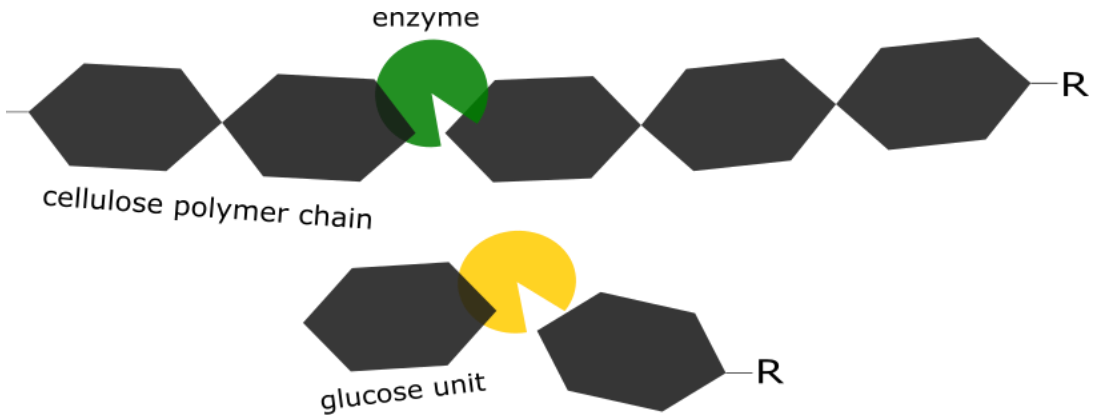
a. cellulose regenerated from ionic liquid
b. CMC crosslinked by Al-salt DS: 0.7
c. nanocellulose
d. methyl cellulose DS: 1.7
e. cellulose acetate DS: 2.41
f. paper partially dissolved by ionic liquid
g. cellophane ★
h. wet strength paper ★
i. cellulose carbamate DS: 0.1
j. butylated hemicellulose DS: 1
k. butylated hemicellulose DS: 0.4
l. butylated hemicellulose DS: 0.2
m. cellulose palmitate DS:1
n. cellulose octanoate DS: 1.2

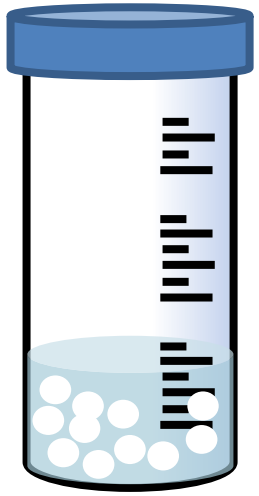
Mechanical properties





Enzymatic degradation

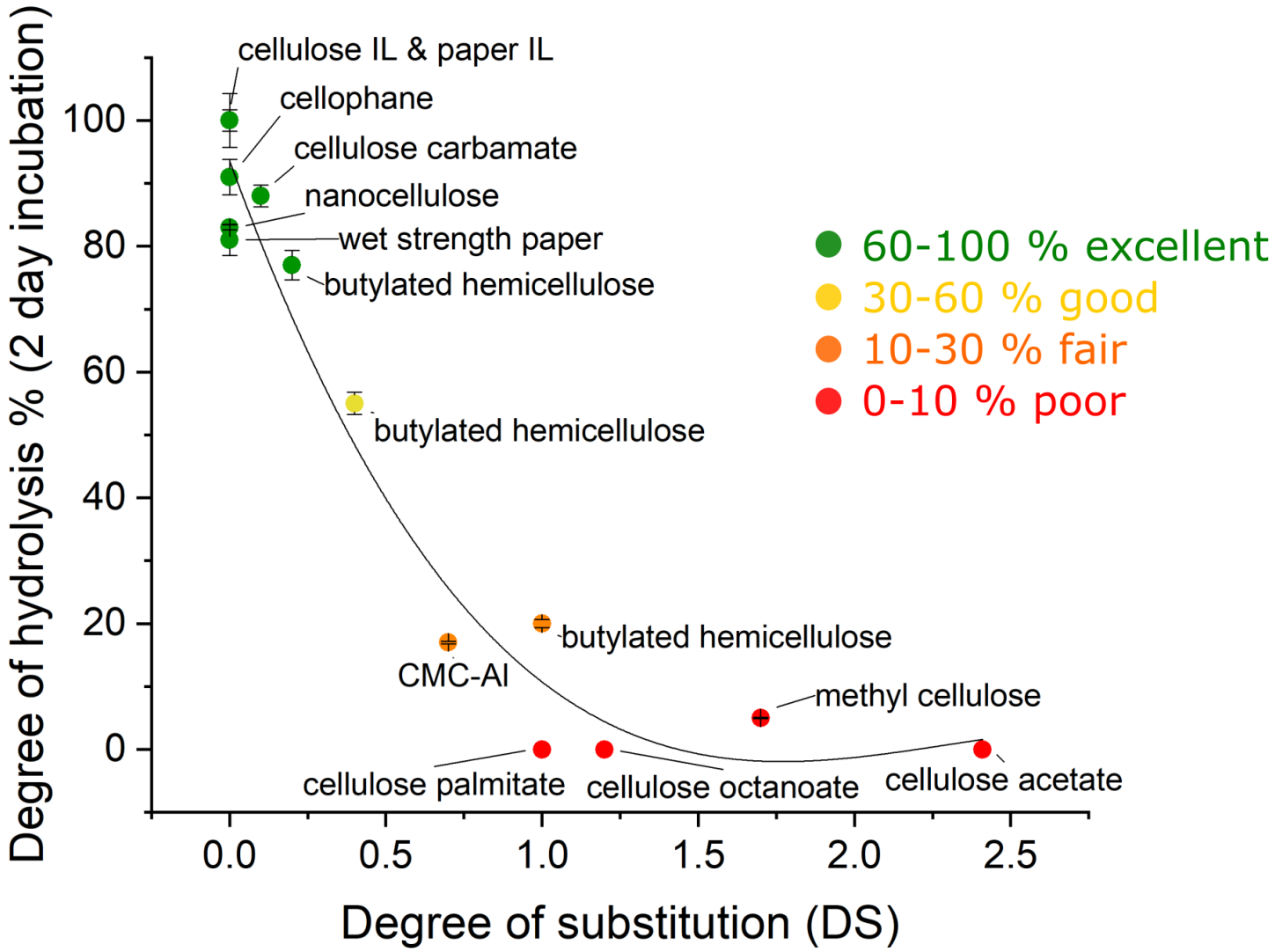




- Determined by enzymatic hydrolysis experiments
  - **100 mg** of each sample cut into small pieces of even size and placed in a **50 ml** falcon tube.
  - Buffer and enzyme mix (commercial) added
    - Enzymes known to degrade cellulose
  - Incubated for **2 days** in 40 °C

- Degree of hydrolysis evaluated by calculating the **reducing sugar content by DNS method**

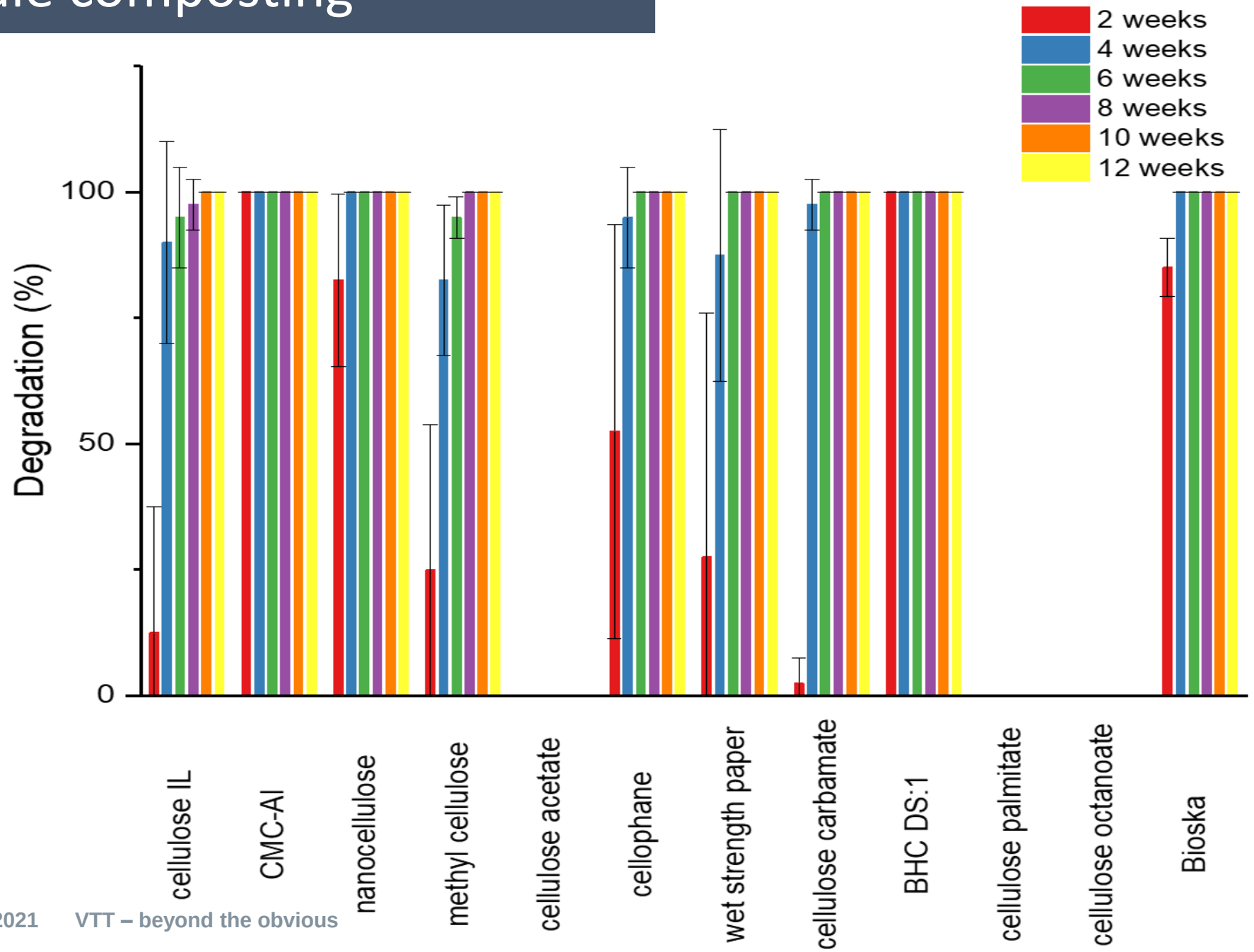
Enzymatic degradation



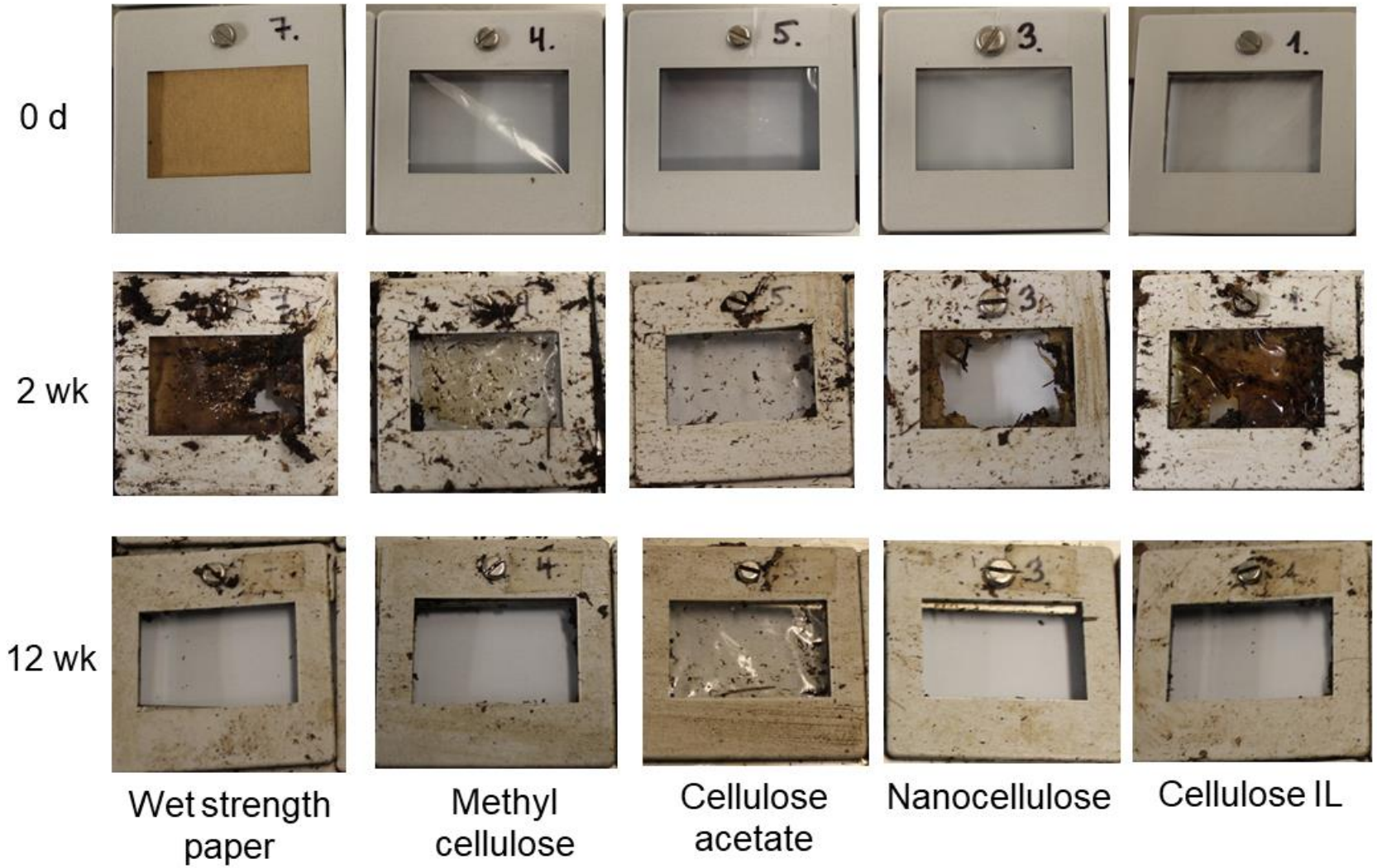
Pilot-scale composting

- **Modified EN standard 14045** (Packaging. Evaluation of the disintegration of packaging materials in practical oriented tests under defined composting conditions).
- Test evaluates degradation (disintegration) of samples during composting
  - Duration of the test: 3 months
- Samples are attached to the frames and degradation evaluated visually
  - Bioska compost bag as reference sample
- Natural composting process with controlled aeration
- Measurement of temperature and carbon dioxide evolution during composting

Pilot-scale composting

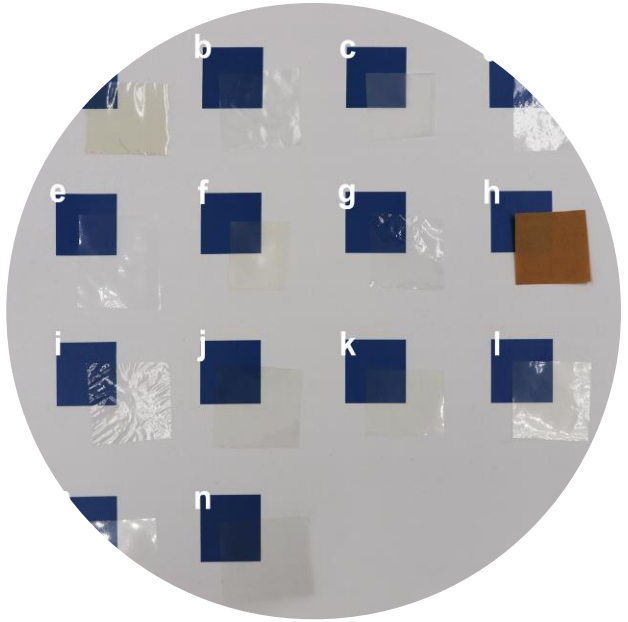


Pilot-scale composting



Conclusion

- Various different cellulose-based films with different properties manufactured
- Enzymatic hydrolysis and pilot-scale composting chosen to evaluate degradation
- DS has clear effect on enzymatic/compost degradation
  - Type and length of substituent have a minor effect
  - Cellulose becomes non-biodegradable when DS ≥ 1
- More information from our article
  - Leppänen, I., Vikman, M., Harlin, A. et al. **Enzymatic Degradation and Pilot-Scale Composting of Cellulose-Based Films with Different Chemical Structures**. J Polym Environ (2019). https://doi.org/10.1007/s10924-019-01621-w



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