WAYS OF MECHANICAL ENERGY IN CELLULOSE: A SIMPLE STUDY

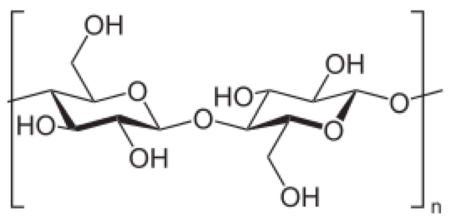
Bychkov Aleksey,[1] Matveeva Anna,[1,2] Bukhtoyarov Vladimir,[1] Podgorbunskikh Ekaterina,[1] Lomovsky Oleg[1]

[1] *Institute of Solid State Chemistry and Mechanochemistry SB RAS,*

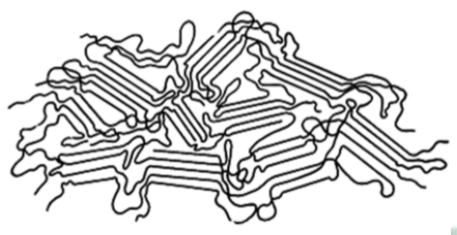
[2] *Novosibirsk State University*

E-mail: matveeva@solid.nsc.ru

What is a cellulose?



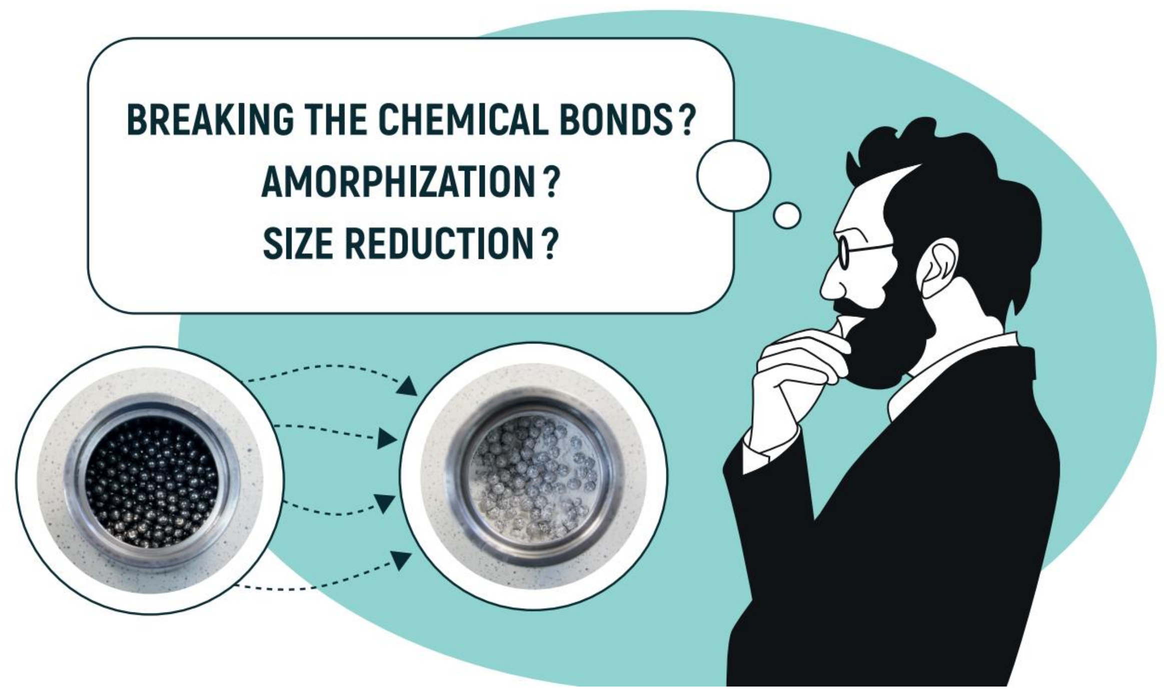
1. Linear polymer of glucose



2. Amorph and crystalline material

3. Microsize powder

Ways of mechanical energy in cellulose:



Simple model:

Base assumption:

effective part **k** of full applied energy **E(T)** which utilized by cellulose $E_{eff}(T)$ is independent of cellulose treating time **T**

$$E_{eff}(T) = k \times E(T)$$

and consist of tree parts:

$$E_{eff}(T) = E_{size}(T) + E_{cd}(T) + E_{dp}(T)$$

- Energy on size reduction, proportional to decrease of surface

$$E_{size}(T) = \alpha(r_0^2 - r_T^2)$$

(r – average radius of cellulose particle)

- Energy on amorphization, proportional to decrease of crystallinity index **CrIn**

$$E_{cd}(T) = \beta(CrIn_0 - CrIn_T)$$

- Energy on depolymerization, proportional to number of ruptured bonds

$$E_{dp}(T) = \gamma\left(\frac{N_0}{N_T} - 1\right)$$

(N – average number of monomers per polymer)

Experiment:

Planetary ball mill AGO-2, alpha-cellulose, set of samples with different treating times.

- Particle size was measured directly by Camsizer XT
- Crystallinity index extracted from Xray diffraction
- Average number of monomers on polymer measured by viscosimeter

Energy consumptions obtained by integration of powermeter curves W(T):

$$E(T) = \int_0^T W(t)dt$$

Mathematical approach:

- To solve overestimated system of i linear equations:

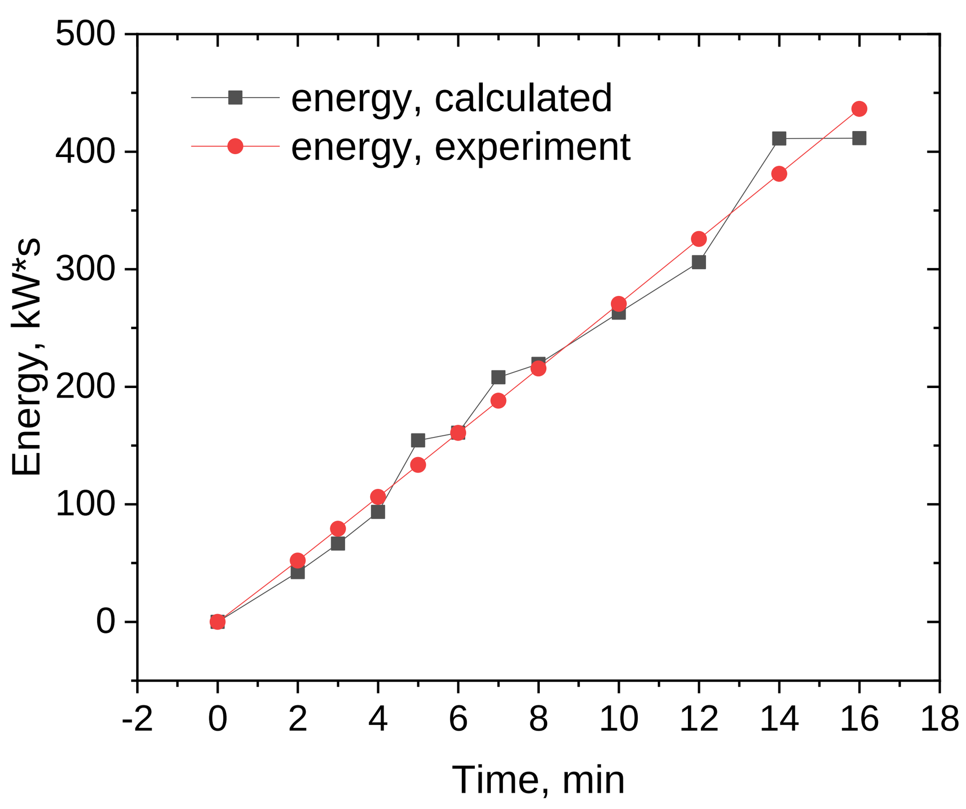
$$E(T_i) = \frac{\alpha_1}{k}(r_0^2 - r_{T_i}^2) + \frac{\beta_1}{k} \times (CrIn_0 - CrIn_{T_i}) + \frac{\gamma_1}{k} \times \left(\frac{N_0}{N_{T_i}} - 1\right)$$

- Obtain each part of effective energy, for example:

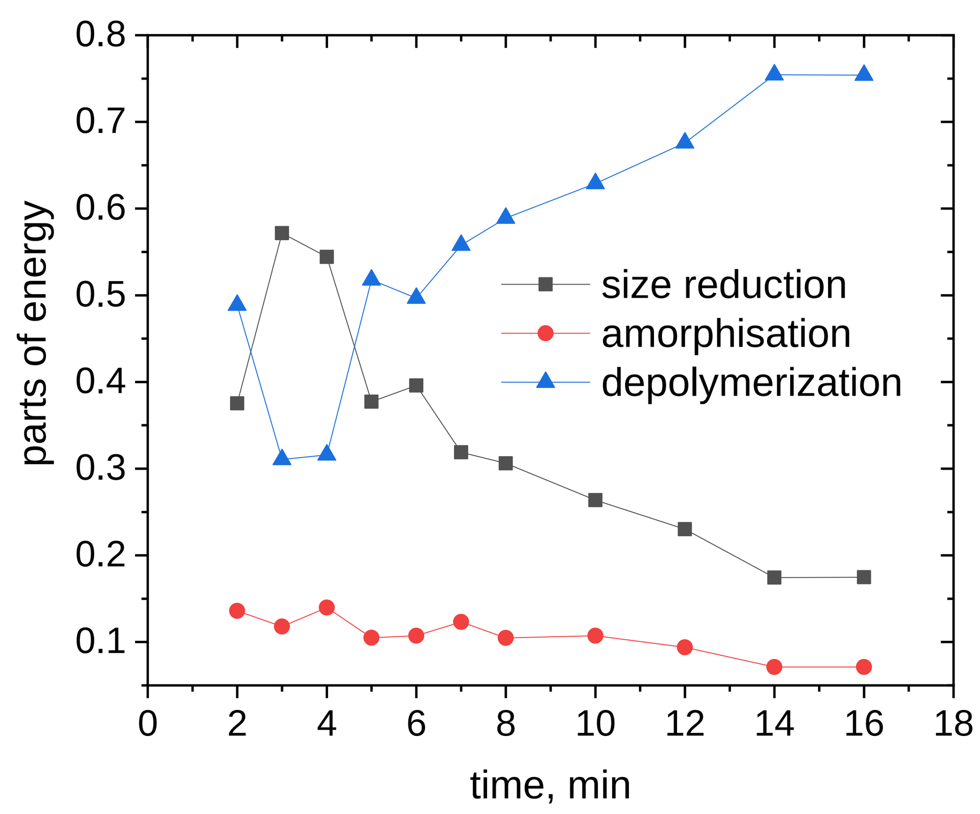
$$\frac{E_{size}(T_i)}{E_{eff}(T_i)} = \frac{E_{size}(T_i)}{k \times E(T_i)} = \frac{\alpha_1}{k \times E(T_i)}(r_0^2 - r_{T_i}^2)$$

To define **relative** part of each energy, one don't need **absolute** value of them! *

Experiment_vs_theory:



Our model is sufficiently good



We can look at each part of energy separately

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Conclusion:

- Even simple model can successfully describe experiment, if it is reasonable
- Mechanical treatment of cellulose at first stages is mainly size reduction
- Depolymerization is main process at latest times
- Amorphization is minor way of energy consumption

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