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Performance of bio-based building materials

Improvement of dimensional stability of wood by silica-nanoparticles

MIKLÓS BAK

FERENC MOLNÁR

RÓBERT NÉMETH

anno 1735
SOPRONI EGYETEM
Megújuló tudásközpont

University of Sopron
Simonyi Károly Faculty of Engineering, Wood Sciences and Applied Arts

Introduction

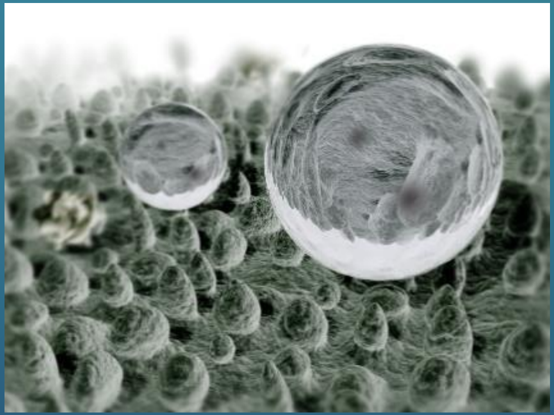
About nanotechnology

- Preparation and research of materials and tools in the range of one to maximum several hundreds of nanometers
- The objective is to modify the material properties by its size and determine the effect of these modifications

Introduction

About nanotechnology

- Nanomaterials have several specific property, which is determined – beyond their chemical composition – by the specific properties of their components and its colloidal structure (size effect of nanoparticles)
- These specific properties exist only in the nano-scale



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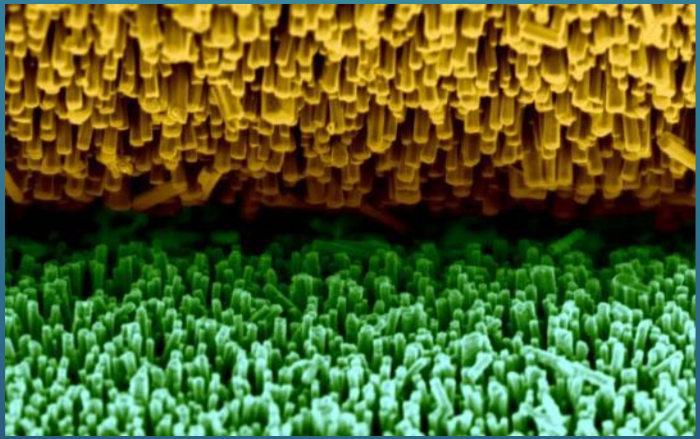
Introduction

About nanotechnology

- With the decreasing size, the physical and chemical properties of the particles are changing remarkably
- Important difference is the significantly increased specific surface area



nanotech.uiowa.edu

Introduction

Nanotechnology in wood science

- Nanotechnology has the potential to show off good results in wood science and technology, by producing new active agents and mode of actions
  - Surface coatings
  - Direct modification of wood
- Different utilization fields:
  - UV-protection
  - Wood preservation
  - Decreasing the hygroscopicity

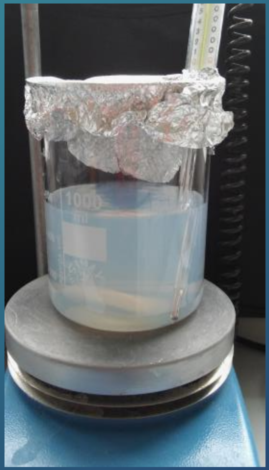
Materials and methods

<u>Treatment #1: Preparation of silica nanoparticles („nano-SiO2 base-sol")</u>

- <u>Step 1:</u> Monodisperse silica sols were prepared by a typical Stöber method:
  - Tetraethoxysilane (TEOS) in ethanol+NH_4OH solution → transparent silica sol
- <u>Step 2:</u> Modifying the hydrophilic silica particles to hydrophobic:
  - addition of 1 wt% hexadecyltrimethoxysilane (HDTMS)

Step 1:

Step 2:



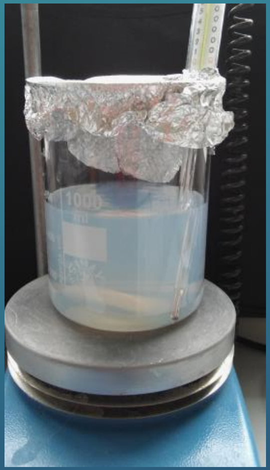
Materials and methods

Treatment #2: Preparation of silica nanoparticles („nano-SiO2 + PDMS”)

- Step 1 & 2: Preparation of „nano-SiO2 base-sol” by the same method
- Step 3: Improvement of the bonding of silica nanoparticles to the wood structure:
    - Addition of polydimethylsiloxane (PDMS) in tetrahydrofurane (THF) solvent to the „base sol”

Step 1:

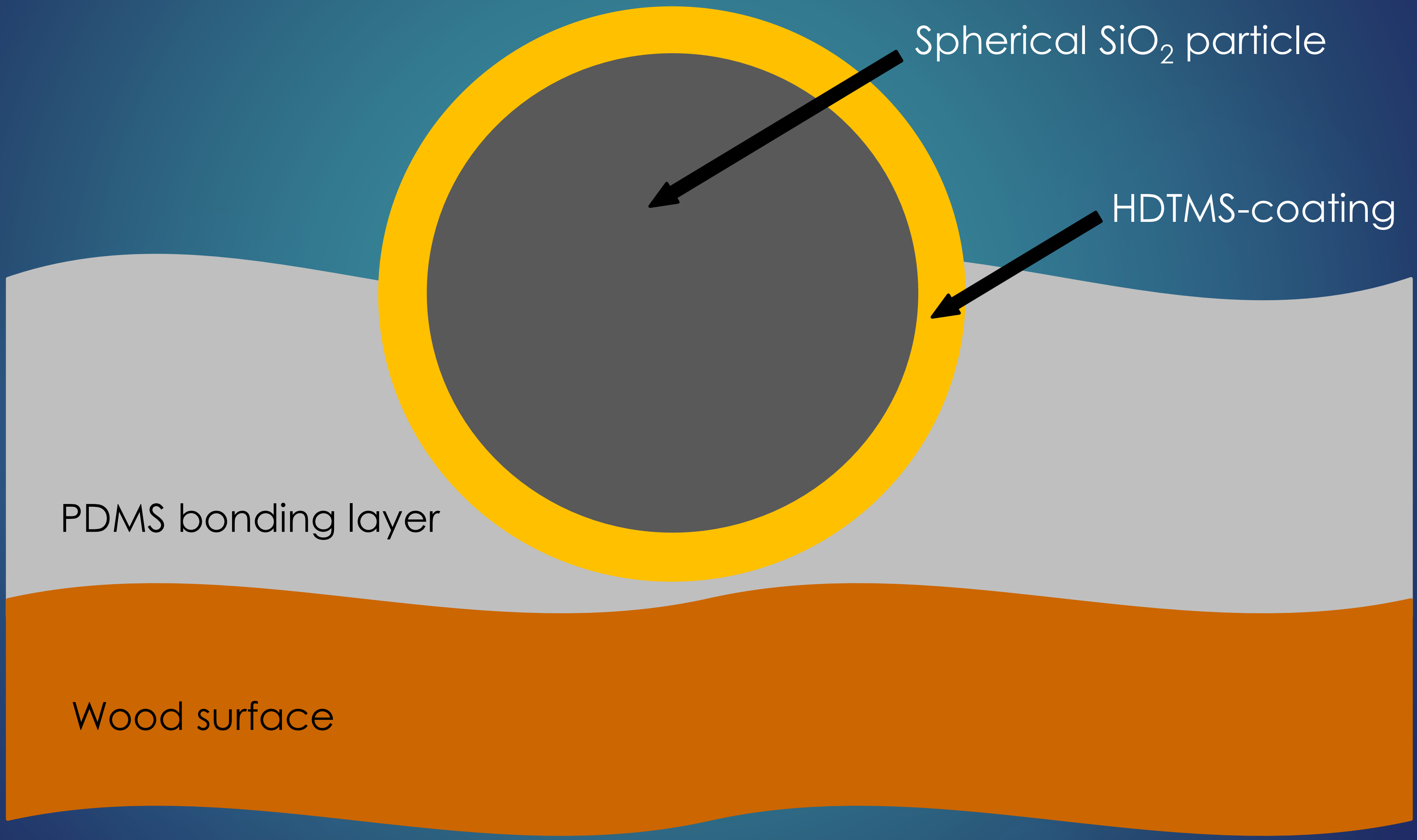
Step 2:



Step 3:

Materials and methods

Treatment system



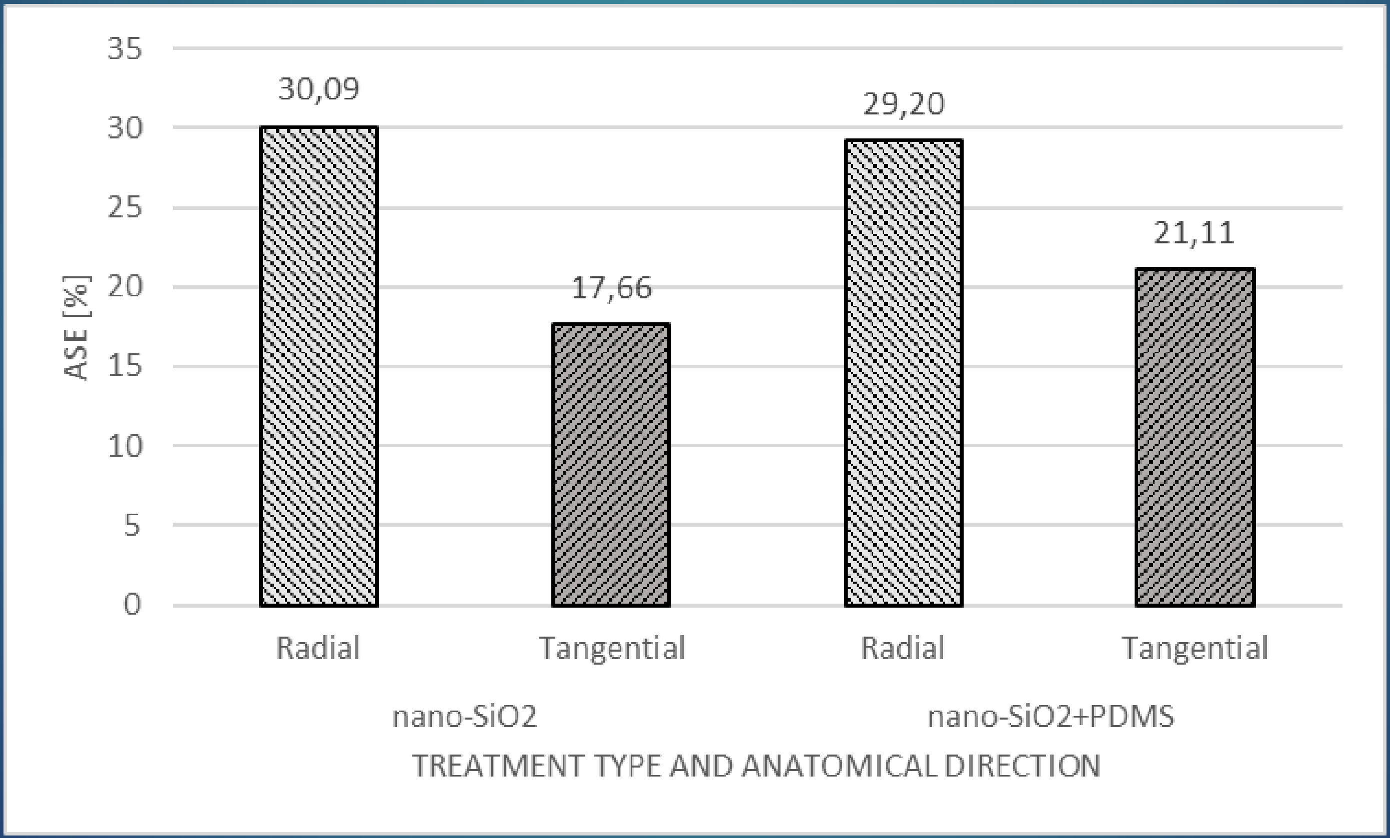
Materials and methods

Test methods

- Investigated wood species:
  - Beech (*Fagus sylvatica*)
  - Pine (*Pinus sylvestris*)
- Treatment of wood material by impregnation
  - Sample size: 20×20×30 mm (R×T×L)
  - Vacuum: 100 mbar, 20 min
  - Atmospheric pressure, 60 min
  - Curing step: 24 h at 110°C in a drying chamber
  - 2 different treatments
- ASE, Swelling anisotropy

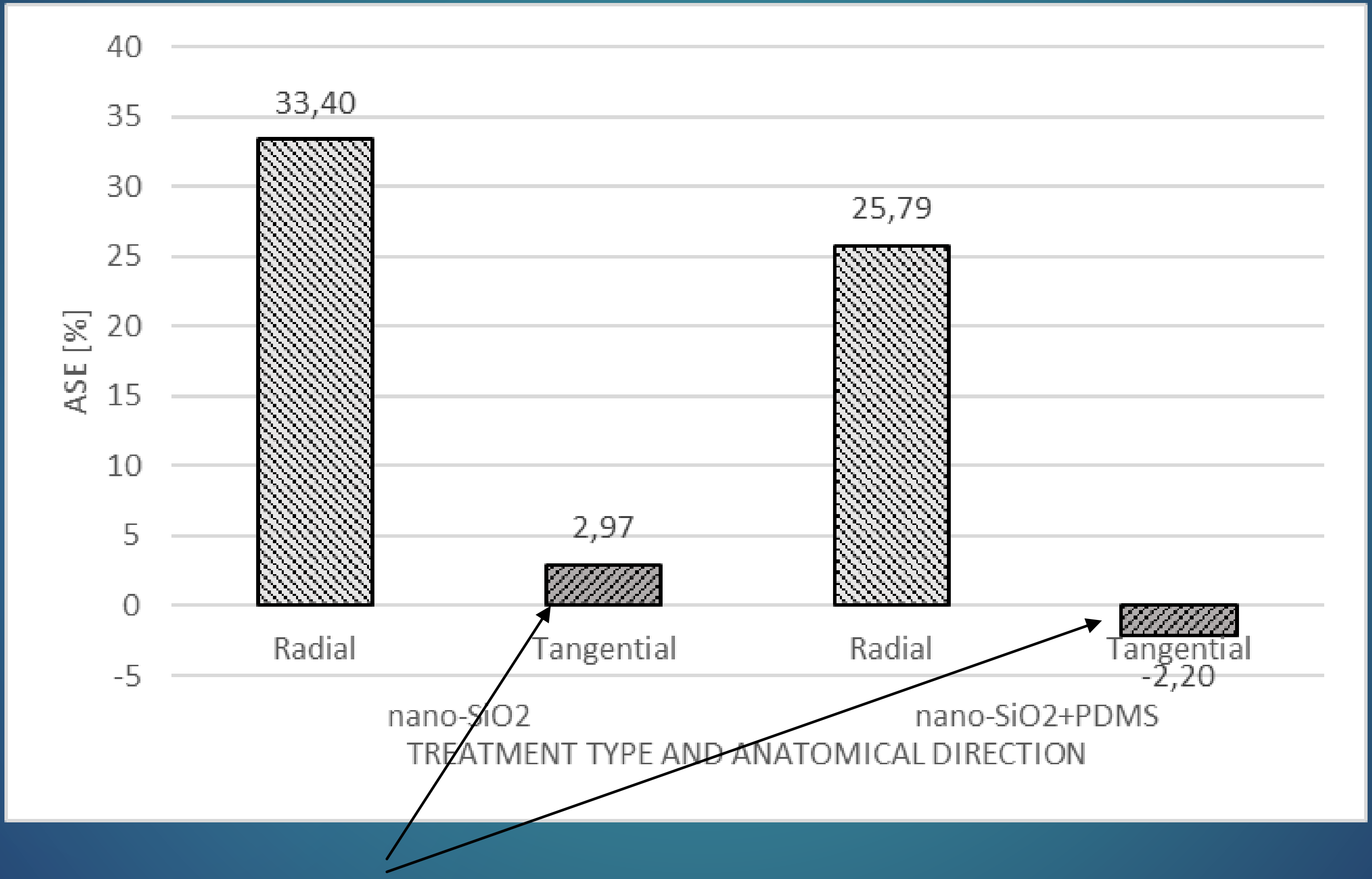
Results

ASE (Beech)



Results

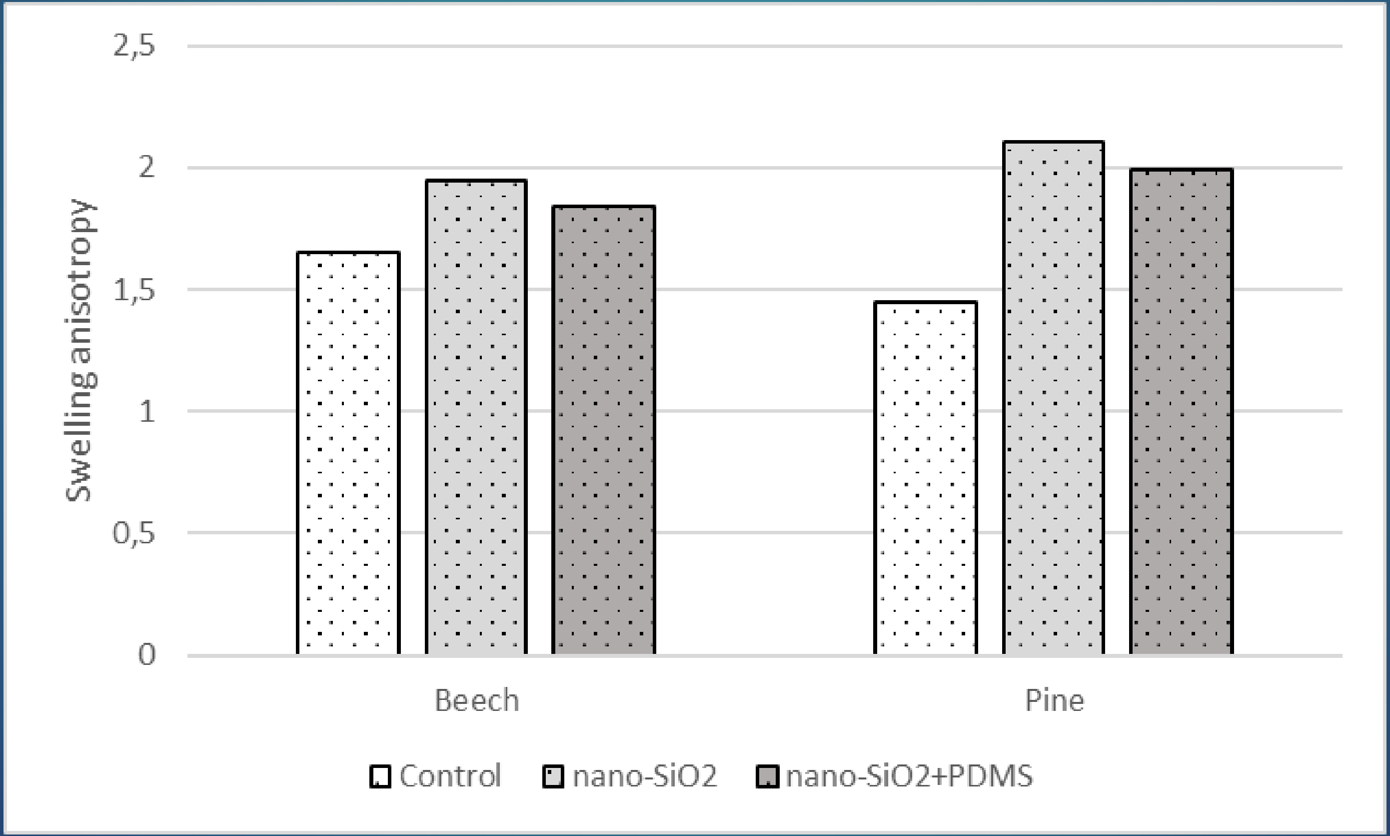
ASE (Pine)



Less effective penetration, inhomogeneous distribution
Retention: ~4,5 kg/m^3 for beech, ~3,8 kg/m^3 for pine

Results

Swelling anisotropy



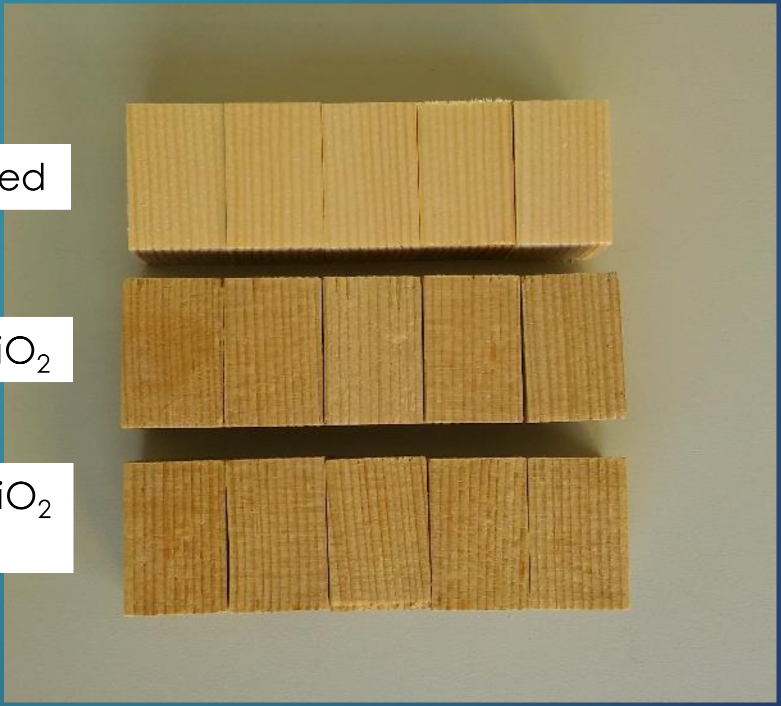
Results

Colour change

Untreated

Nano-SiO_2

Nano-SiO_2 +PDMS



Conclusions

- It is possible to improve dimensional stability of wood by nano-SiO_2 impregnation
- 25-35% ASE in radial direction
- 15-20% ASE in tangential direction for beech, but no change for pine (low permeability?)
- Application of PDMS did not provide better dimensional stability (ineffective curing → catalyst needed)
- Swelling anisotropy was increased significantly
- Slight colour change (whitening, fading)

Acknowledgement

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OTKA

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Thank you for your attention!