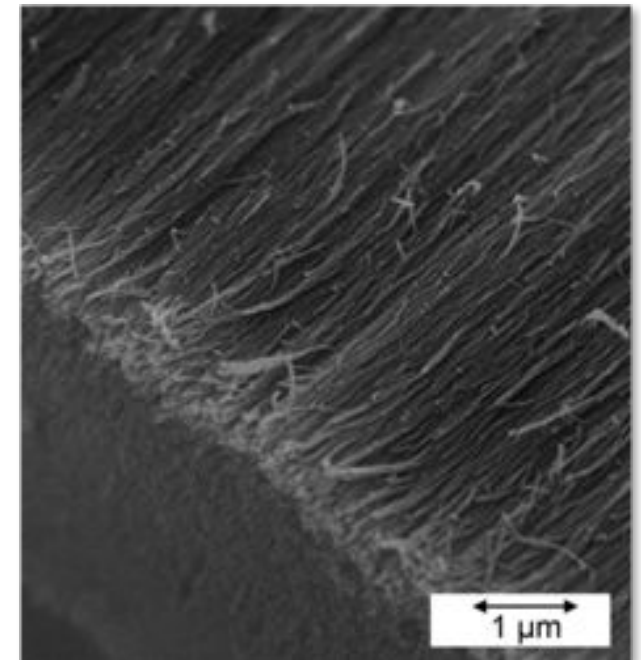
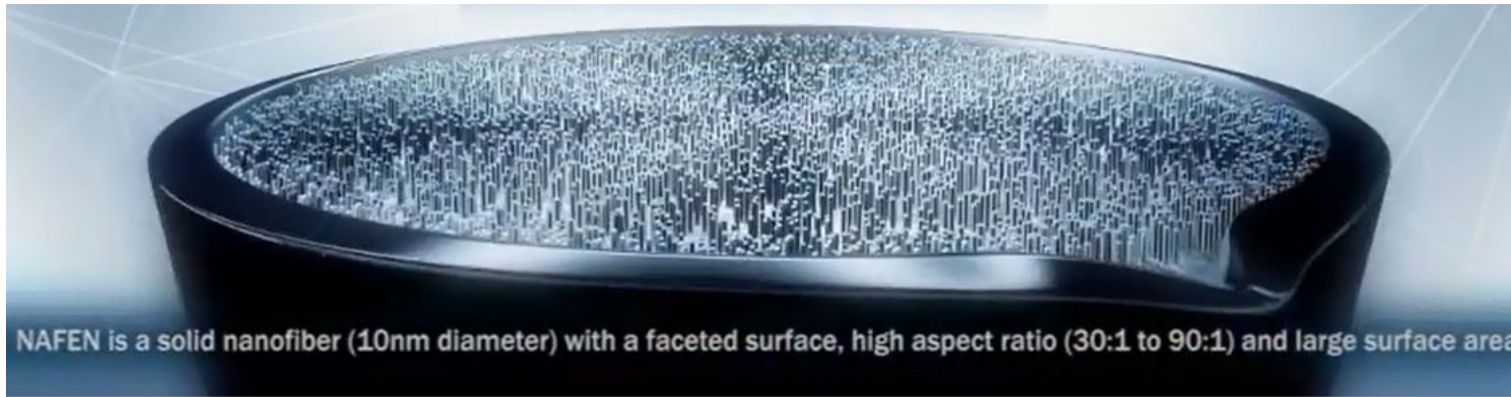
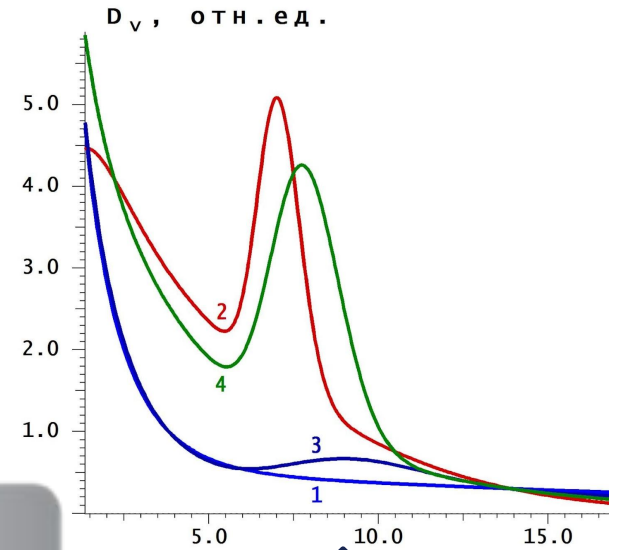
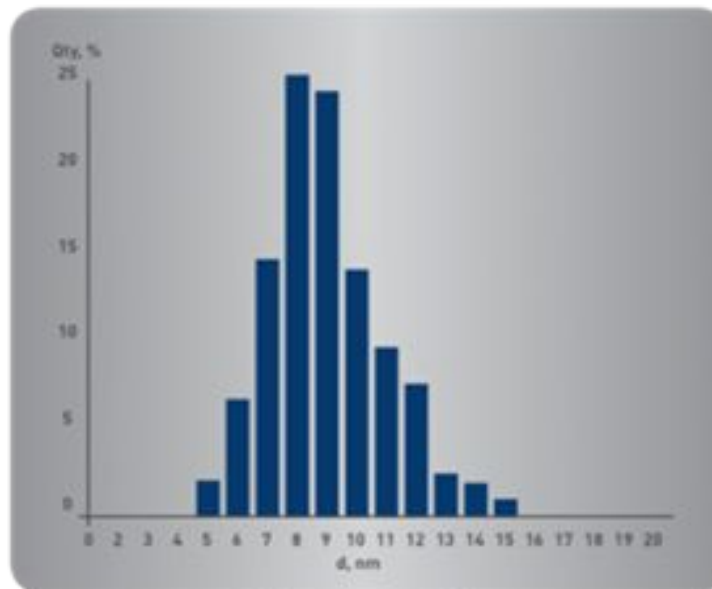
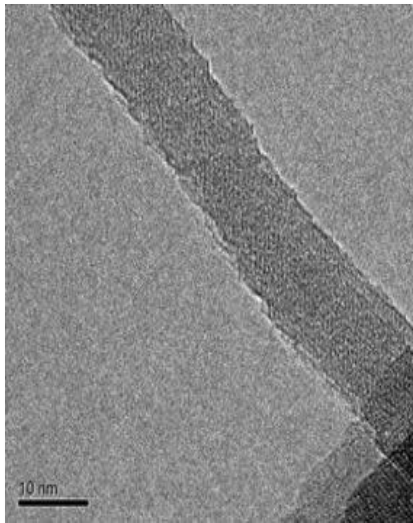
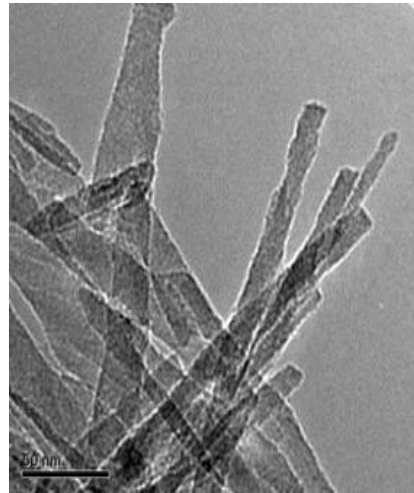
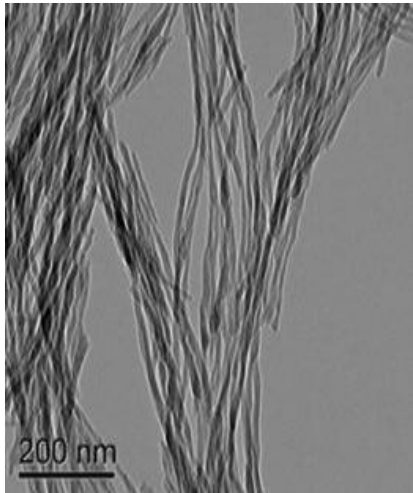





Nanofibers of aluminum oxide

Nafen is produced from melt: industrial-scale technology






small-angle scattering (SAXS);
also indicate high degree of alignment

Parameter	value
Phase	gamma / chi ~ 15:85 *
Mean fiber diameter, nm	7-10
Fiber length, mm	1–150
Specific surface area (BET), m ² /g	100-150
Purity, %	99.7
Bulk density, g/cm ³	0.1 to 0.4

* - phase composition can not be accurately quantified because of lack of structure model for χ -phase

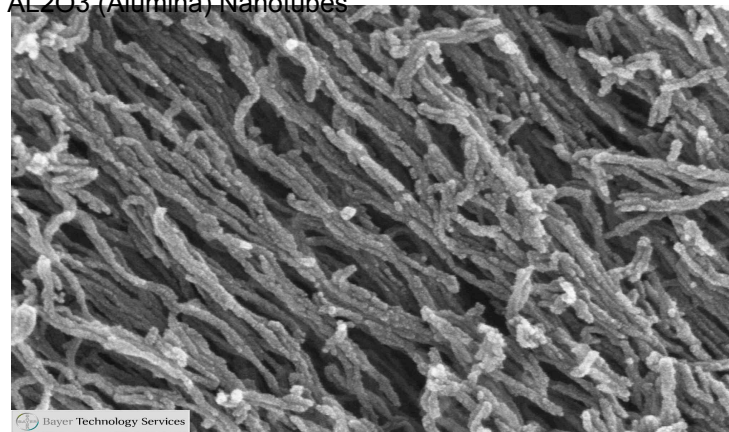
Reference 1:
AlOOH “aerogel” (FEI)



Reference 2:
Nano Technology Inc. (Korea):

“diameter is approximately 5-10 nm, and the aspect ratio is in the 50 to 200 range”

AL₂O₃ (Alumina) Nanotubes



Bayer Technology Services

99360 :
1

200n
m

3258 *Bull. Korean Chem. Soc.* **2012**, Vol. 33, No. 10
<http://dx.doi.org/10.5012/bkcs.2012.33.10.3258>

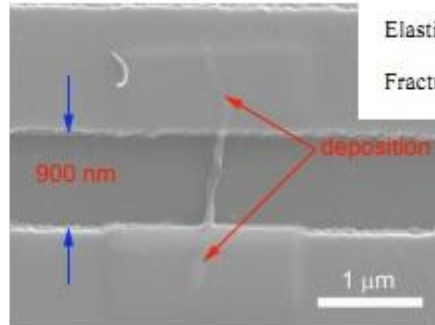
Byung-Joo Kim et al.

Effects of Surface Nitrification on Thermal Conductivity of Modified Aluminum Oxide Nanofibers-Reinforced Epoxy Matrix Nanocomposites

Byung-Joo Kim, Kyong-Min Bae,[†] Kay-Hyeok An,^{*} and Soo-Jin Park^{†,*}

Mechanical properties of individual fiber

Calculation of Elastic modulus, fracture strength, and fracture energy of Nafen fibers



Elastic modulus: 402.8 ± 99.3 GPa.

Fracture strength: 12.2 ± 3.2 GPa.

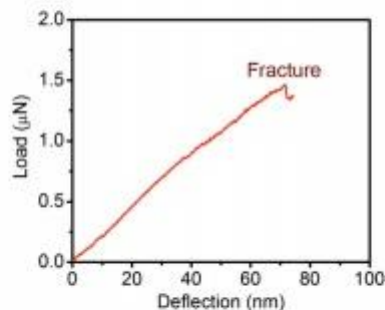
[CNTs \(Wiki\):](#)

[Young's modulus](#) on the order of 270 - 950 [GPa](#) and [tensile strength](#) of 11 - 63 GPa

$$E = \frac{FL^3}{192d_n I} = \frac{K_n L^3}{192I}$$

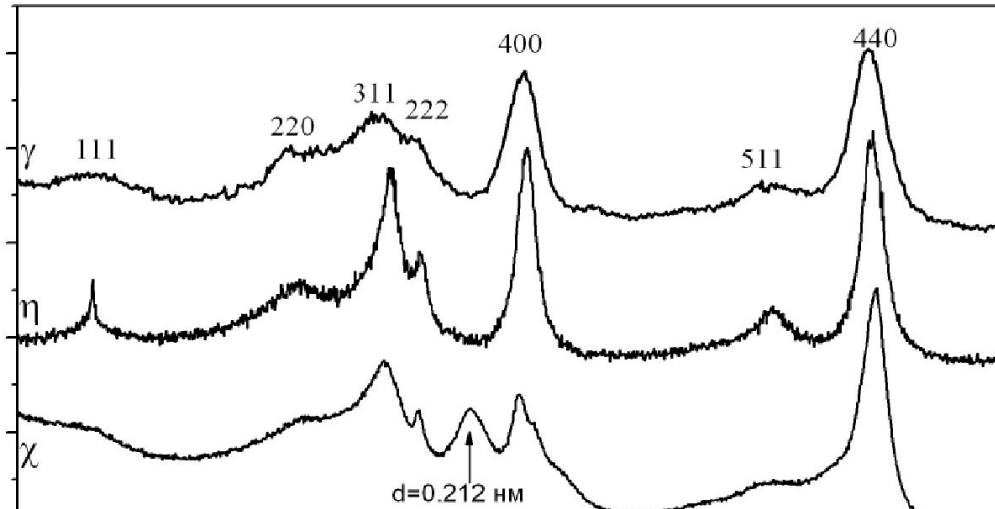
where I is the moment of inertia, L is the suspended length of the sample, and F is the applied load at its midpoint position. K_n , the spring constant of the sample.

Calculation of fracture strength



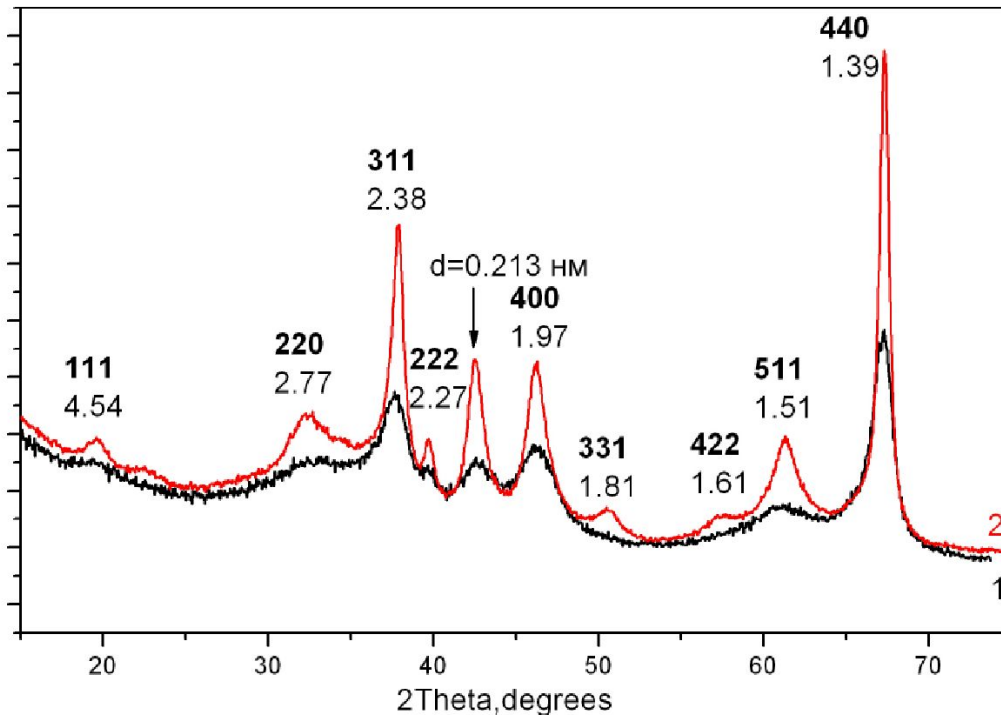
$$\sigma = \frac{FL}{2\pi r^3}$$

Where F is load when the nanowire cracks, L is the suspended length of the sample; r is the radius of nanowire.



Typical diffraction patterns for low-temperature phases of alumina

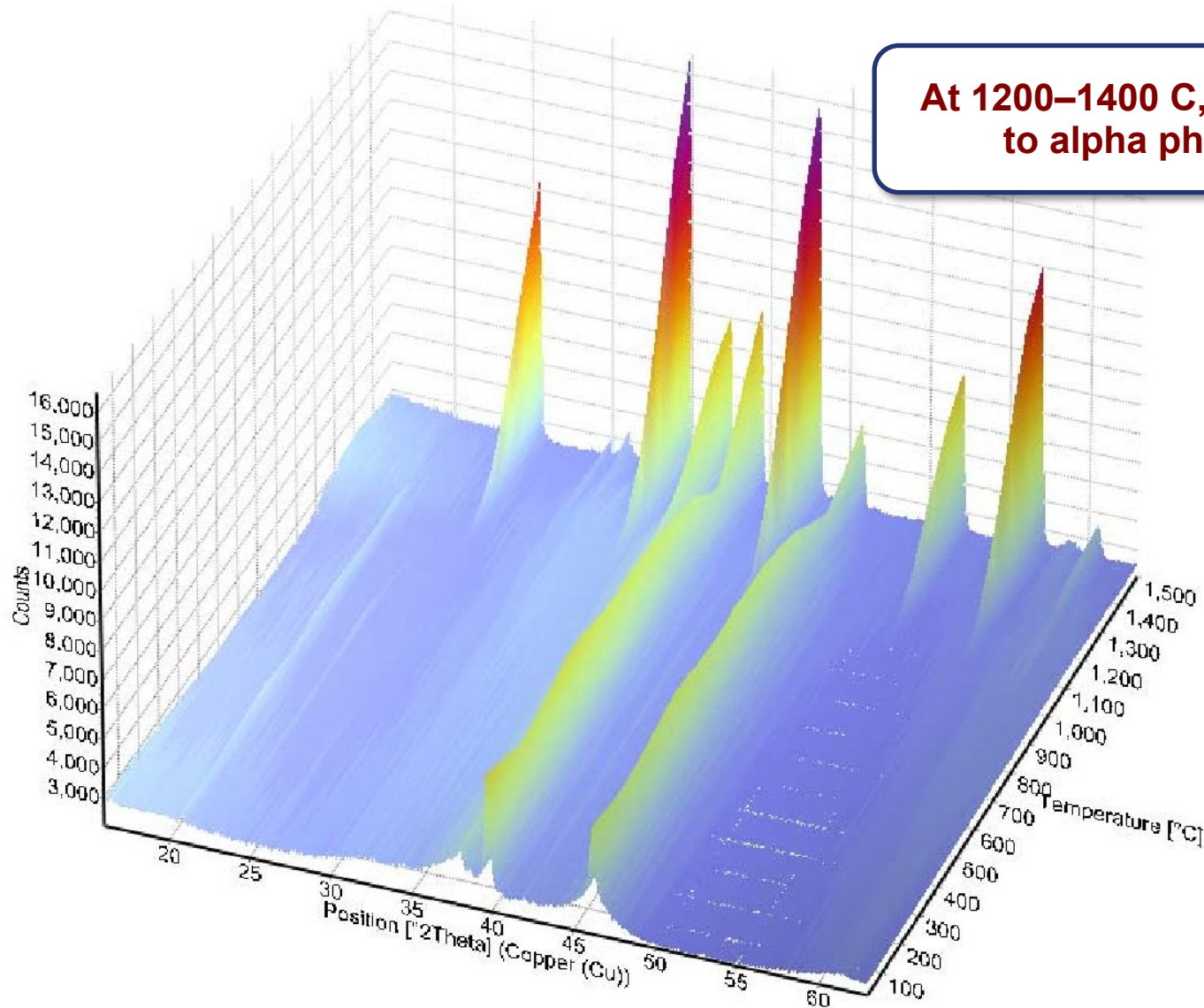
- chi is identified by the peak at $2\theta=42.8$



Diffraction patterns of two samples of Nafen

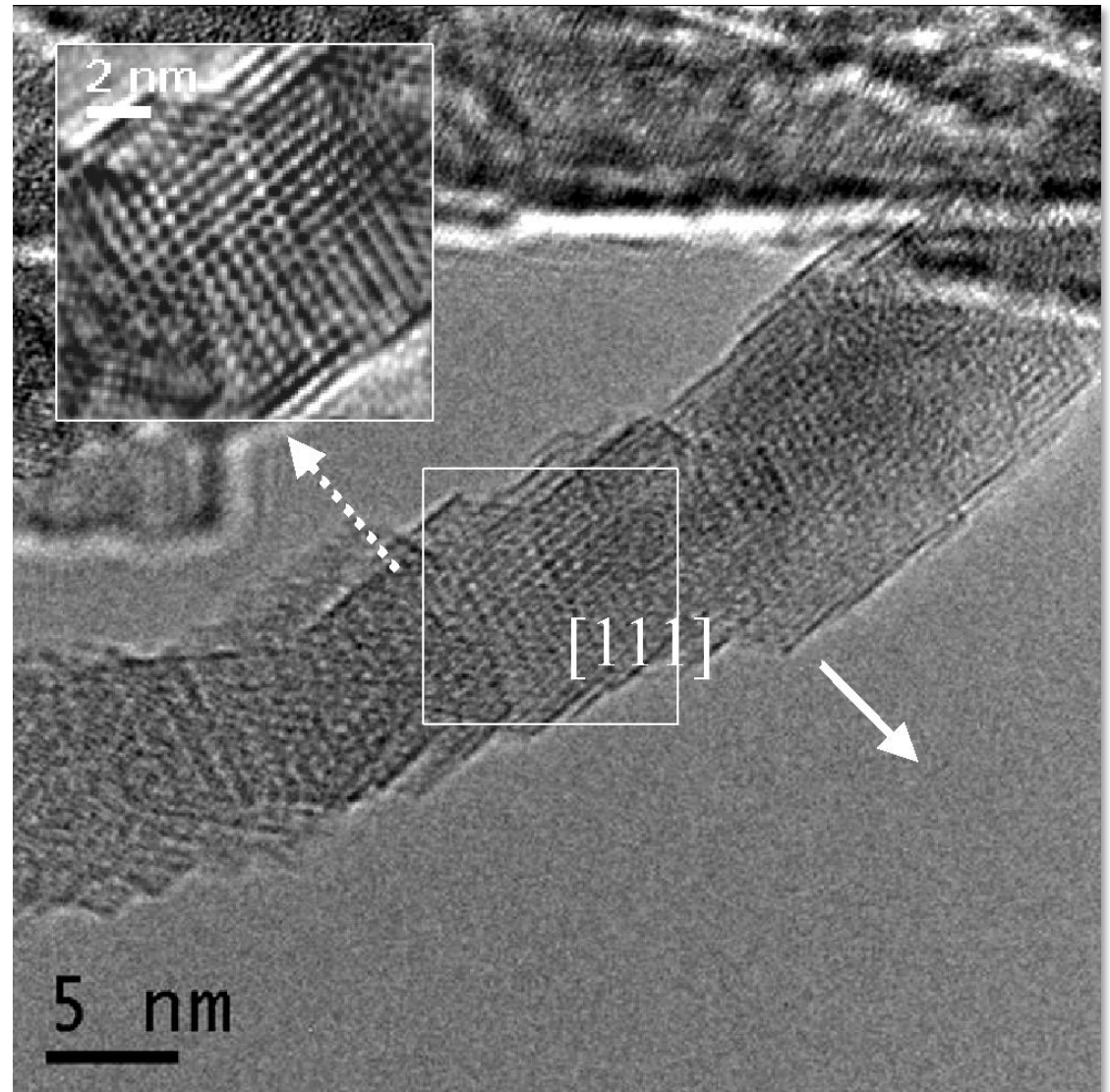
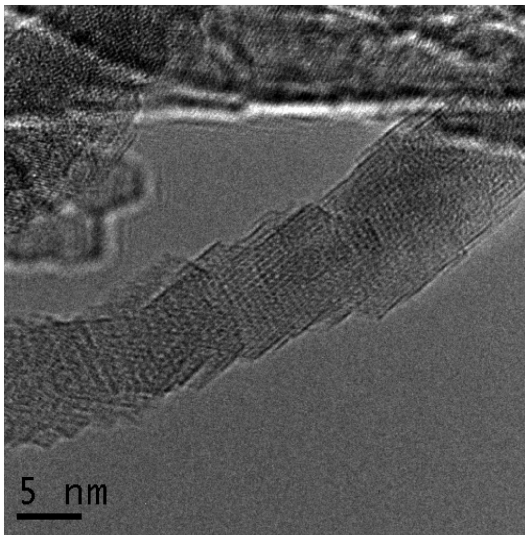
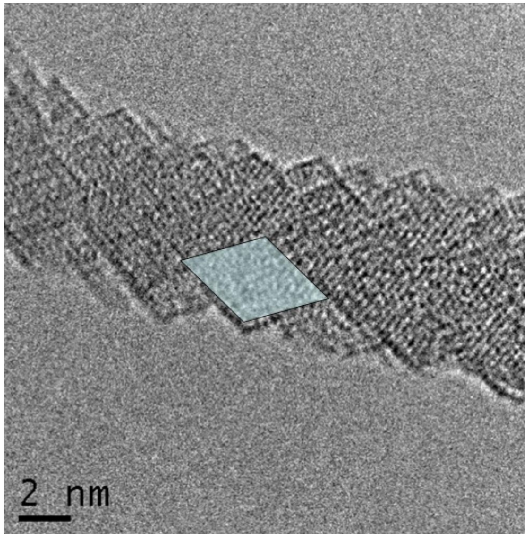
- the phase is identified as mostly chi, with some gamma
- crystallite (CSR) size 50-100 nm

Nafen fibers are polycrystalline alumina in gamma and chi phases



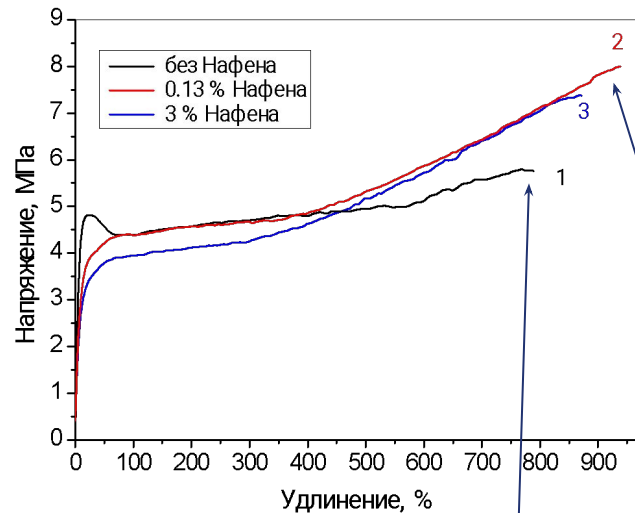
At 1200–1400 C, transformation to alpha phase occurs

The surface is 'saw-shaped' (TEM)



Main application: reinforcing filler for thermoset-based adhesives

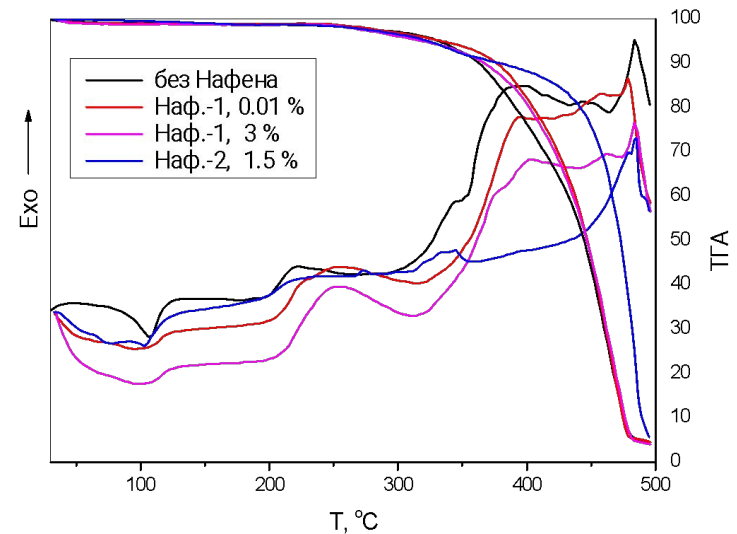
EP-PP copolymers:
“as co-monomer”



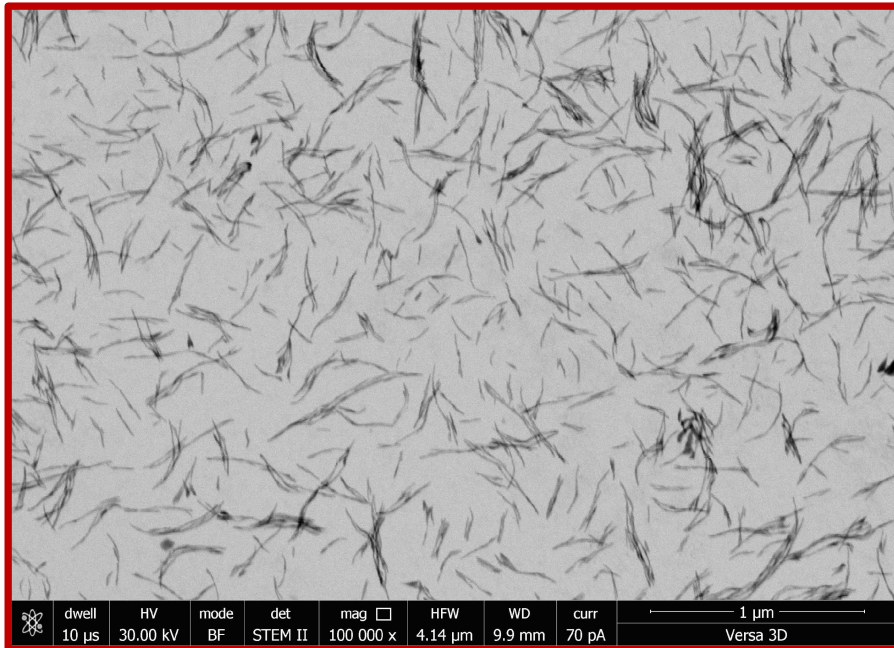
790% / 5.8 MPa

940% / 8.0 MPa

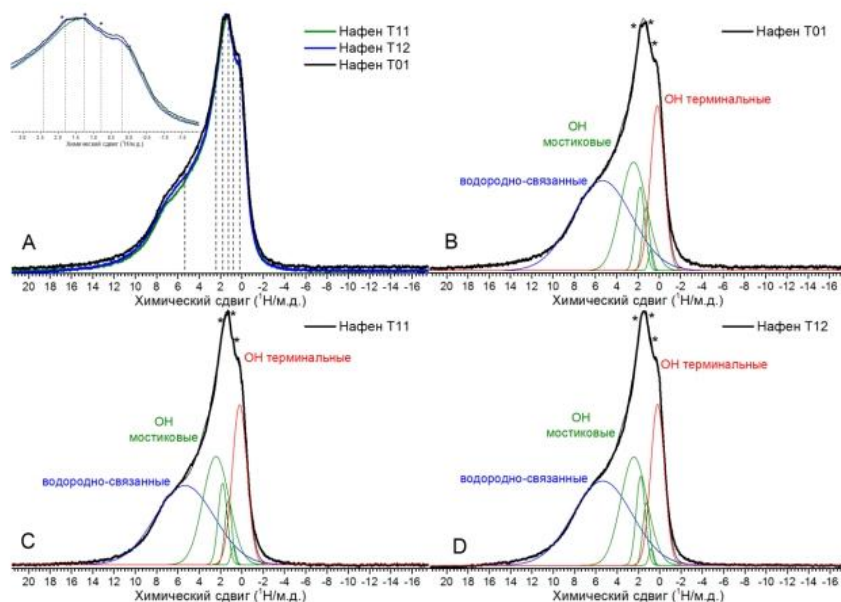
Surface treatment type affects
the performance, including level of
TOD stability enhancement



Reference:
N.M. Bravaya et al.,
J. Appl. Polymer Sci. (2017) –
accepted for publication



Ultrasonic dispersion and/or targeted surface treatment (functionalization) allows good (almost to single fiber) level of dispersion



¹H MAS NMR:

three types of surface protons:

- terminal

- bridge

- hydrogen-bonded

IR spectroscopy / CO absorption:

only weak and medium-strength

Brønsted and Lewis centers are present:

max Q(LC) = 39 kJ/mole - considerably lower than for “conventional” Al₂O₃ types

Nafen as support for heterogeneous catalysts: first trials



1) HDC of halogen-aromatic compounds:
application for waste treatment
(unpublished)

2) Emulsion hydrogenation
of substituted phenols
(unpublished data):

23 compounds tested

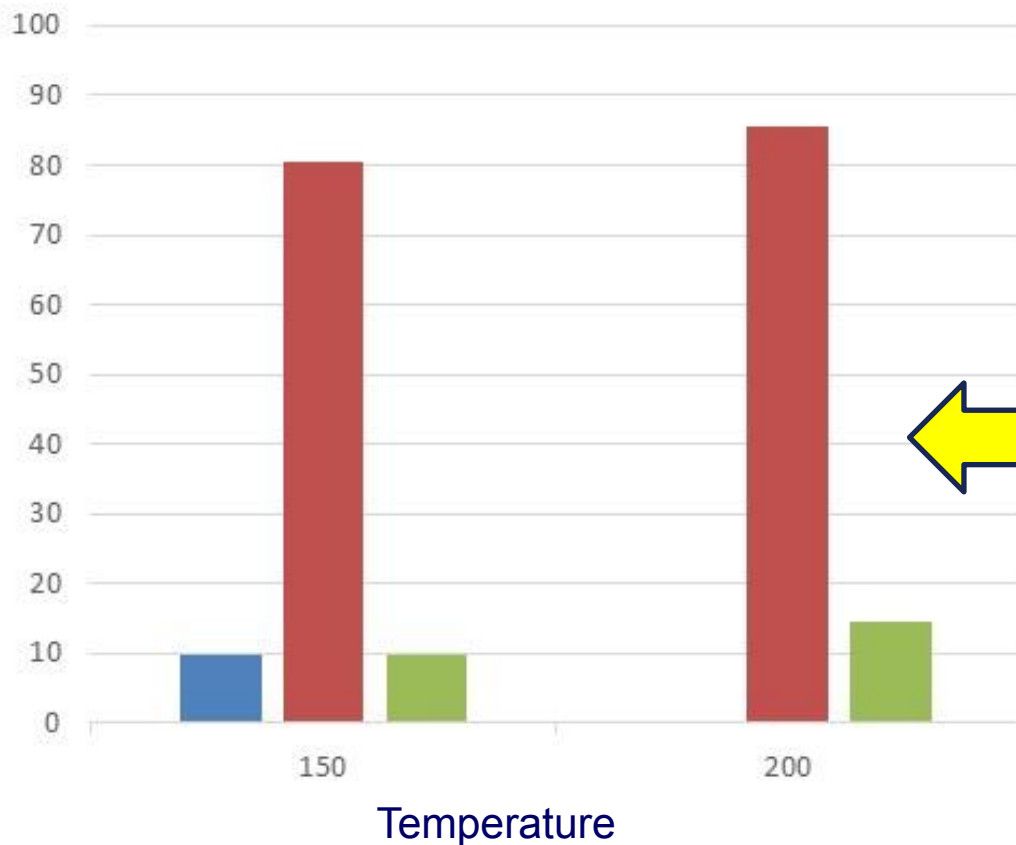
Nafen-supported catalyst
showed up to 95% yield and
up to 94% selectivity

Cl-benzene

cyclohexane

benzene

2) Low-temp CO-oxidation
95% conversion already
with unmodified commercial
catalyst



- 1) **low-T Al₂O₃ polymorph**
- 2) **relatively high SSA and “highly-defective” surface:**
allows easy anchoring of catalytically active components
- 3) **low acidity: no / minimal side reactions → selectivity**
- 4) **surface chemistry can be tailored:**
 - **three subtypes of Nafen available**
 - **functionalization is possible**
- 5) **ready masterbatches for liquid dispersion type processes
can be produced**
- 6) **“bonus” reinforcement effect (?)**

Thank You for Attention