Technical University of Liberec
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Nanomodification of geopolymer composites

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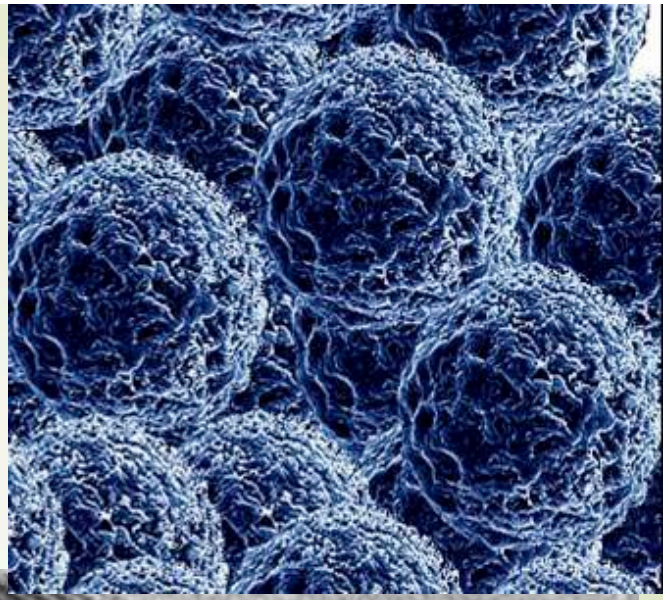
GeopolymerCamp 2018

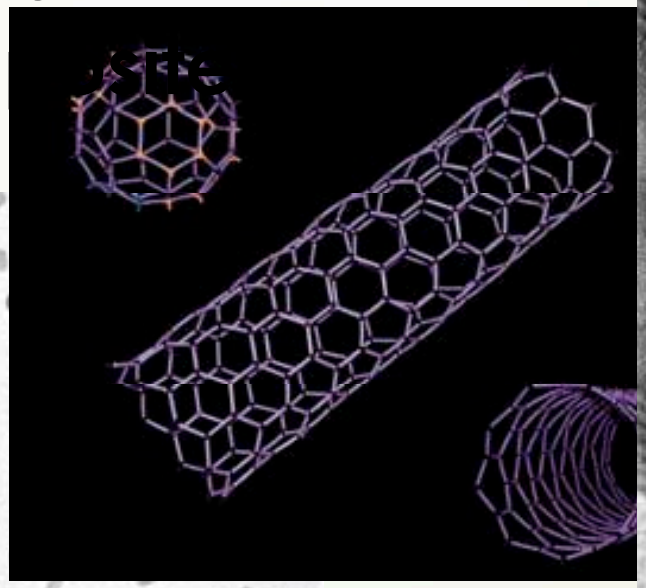
Content of presentation

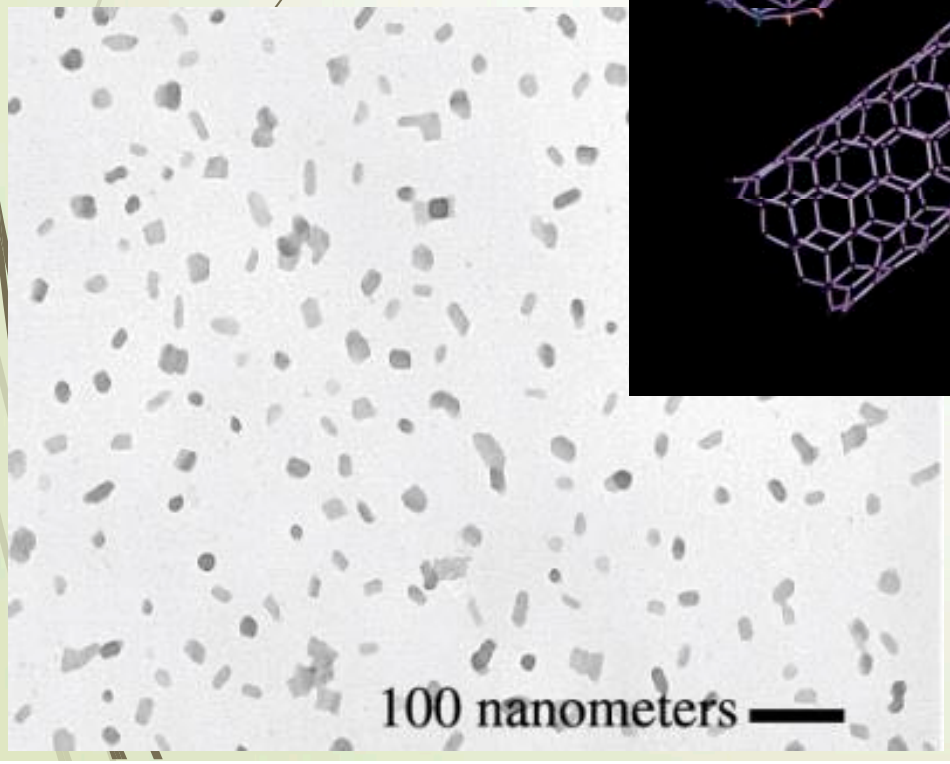
- **Introduction** - GP and nano
- **Experiments** - **fibres** in geopolymer matrix
  - **surface** modification of GP
- **Results**

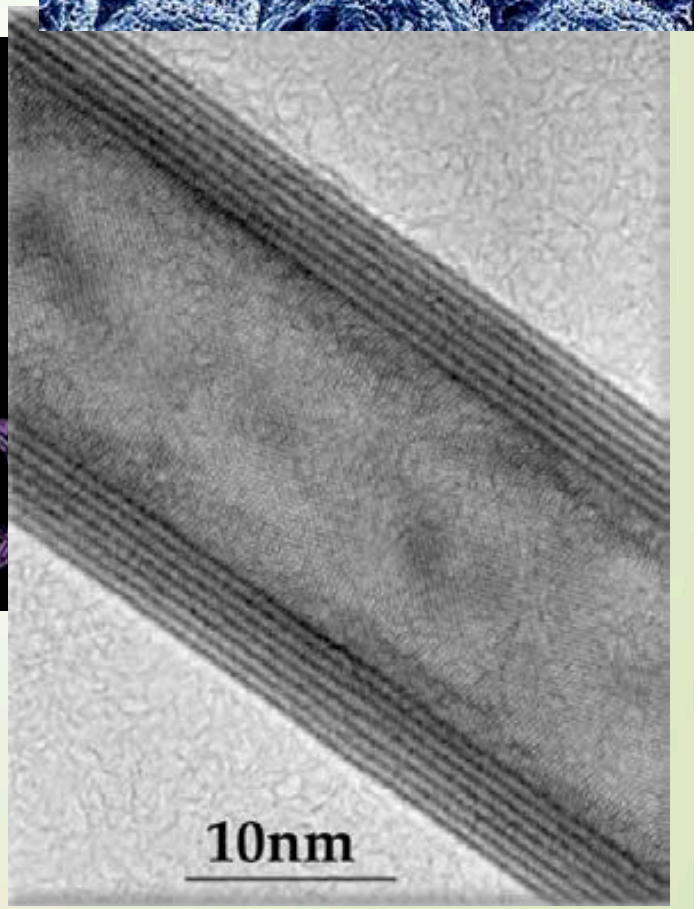
Nanomaterials

0D – nanoparticles
1D – nanofibers
2D – nanolayers
3D – nanocom



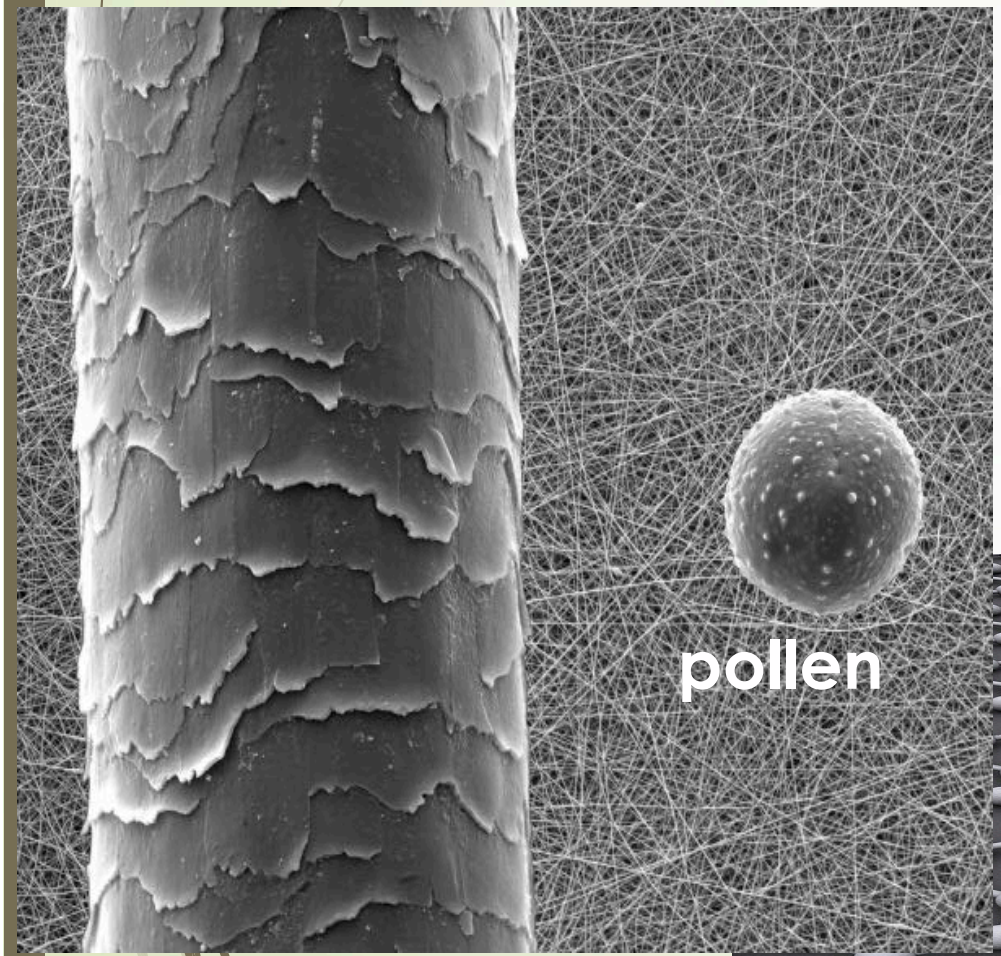






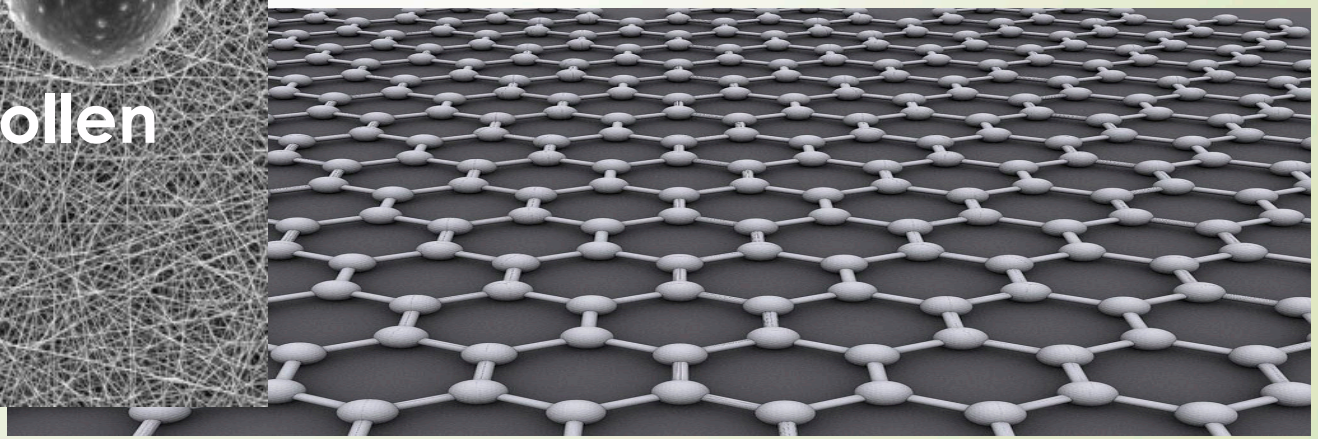
Nanomaterials

Preparation of geopolymer composites with different types of fibres and their characterizations

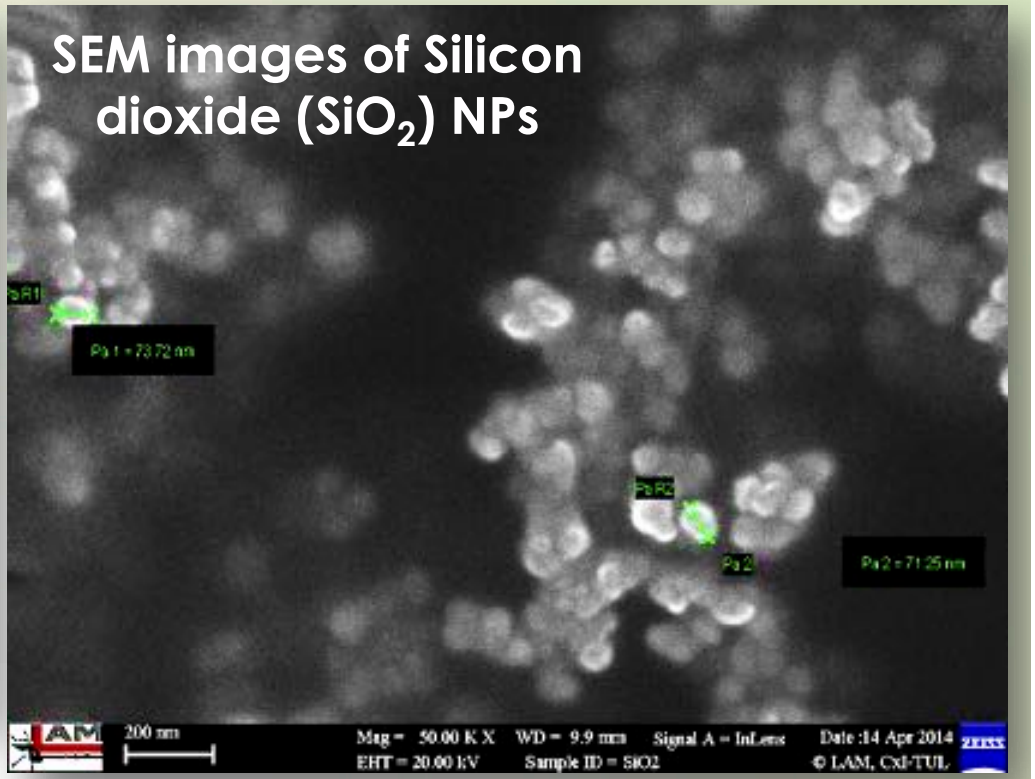


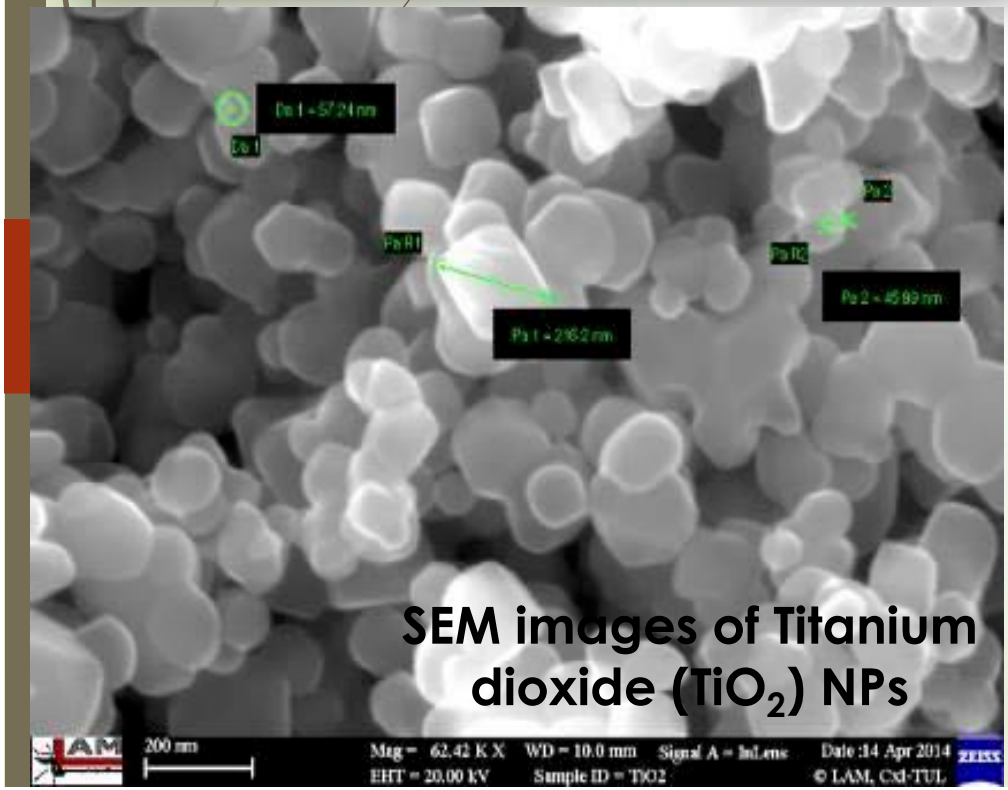
- Carbon fibres and NPs;
- Silicon dioxide fibres;
- Al2O3 NPs;
- Basal net.

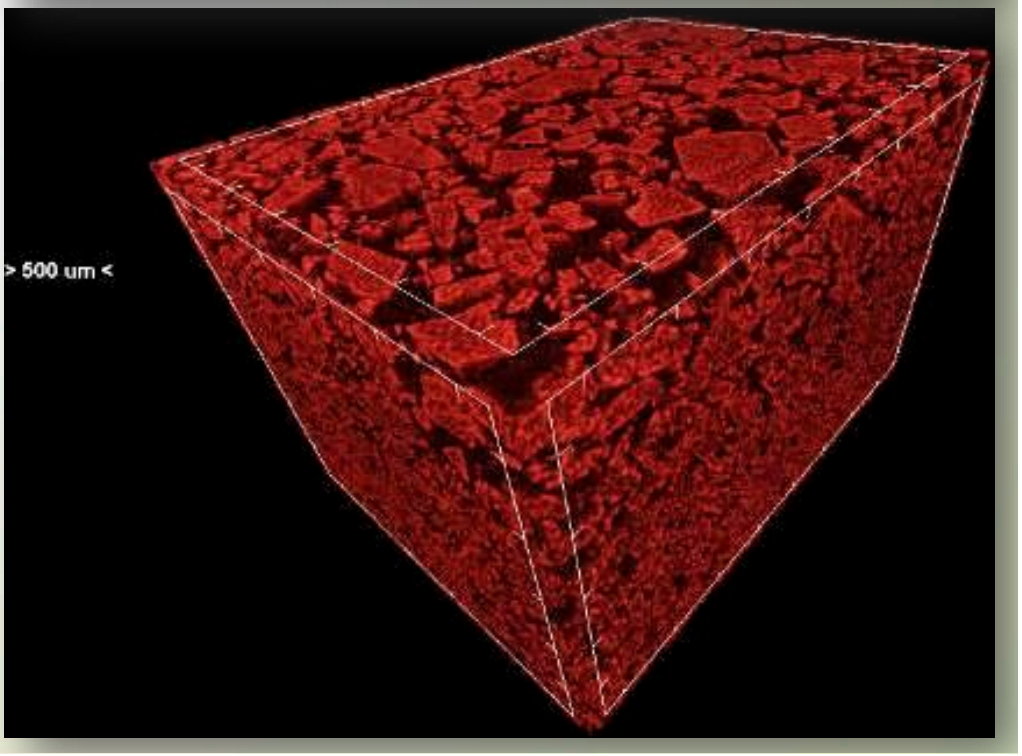
➨Mechanical properties of fibres reinforced geopolymer matrix.




5
SEM images of silver nitrate ($AgNO_3$) NPs
1 µm
Mag = 5.00 K X WD = 8.2 mm Signal A = SE2 Date :27 Feb 2015
EHT = 5.00 kV Sample ID =
© LAM, Cxl-TUL

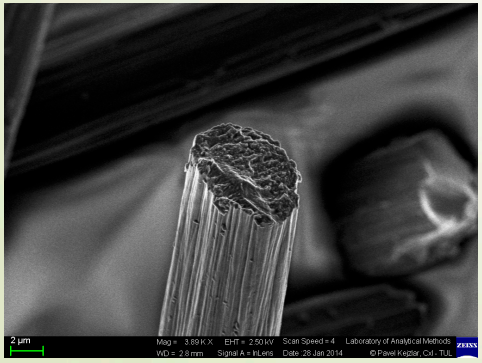

SEM images of Silicon dioxide (SiO_2) NPs
Pa1 = 73.72 nm
Pa2 = 71.25 nm
200 nm
Mag = 50.00 K X WD = 9.9 mm Signal A = InLens Date :14 Apr 2014
EHT = 20.00 kV Sample ID = SiO2
© LAM, Cxl-TUL

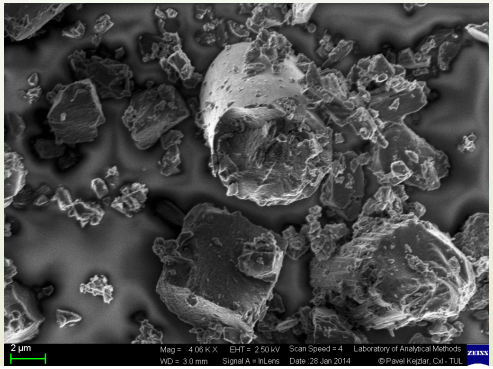

Pa1 = 57.24 nm
Pa2 = 45.89 nm
Pa1 = 216.2 nm
SEM images of Titanium dioxide (TiO_2) NPs
200 nm
Mag = 62.42 K X WD = 10.0 mm Signal A = InLens Date :14 Apr 2014
EHT = 20.00 kV Sample ID = TiO2
© LAM, Cxl-TUL

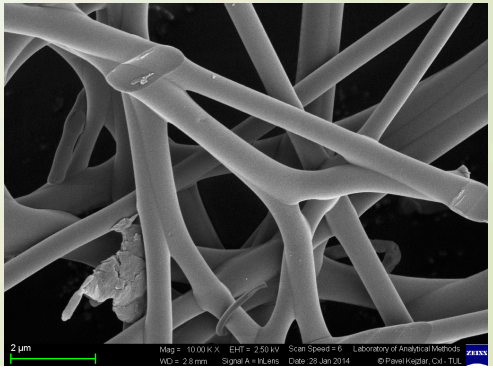

> 500 um <

Experiment - influence of fillers in geopolymer matrix

% (wt)	Carbon fiber (μm)	Carbon fiber(subμm)	SiO2(nm)	C (subμm) +SiO2(nm)
	3	0.1	0.1	0.1+0.1
	5	0.3	0.3	0.3+0.3
	7	0.5	0.5	0.5+0.5
	8	0.7	0.7	0.7+0.7
	10	1	1	1+1
Price	0.036÷0.06 EUR/g		8 EUR/g	
Produced	Aerospace research	Miiling from	Kertak nanotechnology	
	and test institute in Prague	Carbon fiber in μm		







Preparation samples

- Mix bauxis and activator in 3 min by hand, mix the mixture during 5 min by mixer.
- Add fibres into mixture and continue mixing it by mixer about 5 minutes.
- Vibrate the mixture in the mould – 3 min.
- Cure specimens in furnace.

Specimens testing:

- Testing after 28 days
- According to **ASTM C 39/C 39M – 01**
- Calculate compressive strength:

$R_m = F_{max}/S_0$

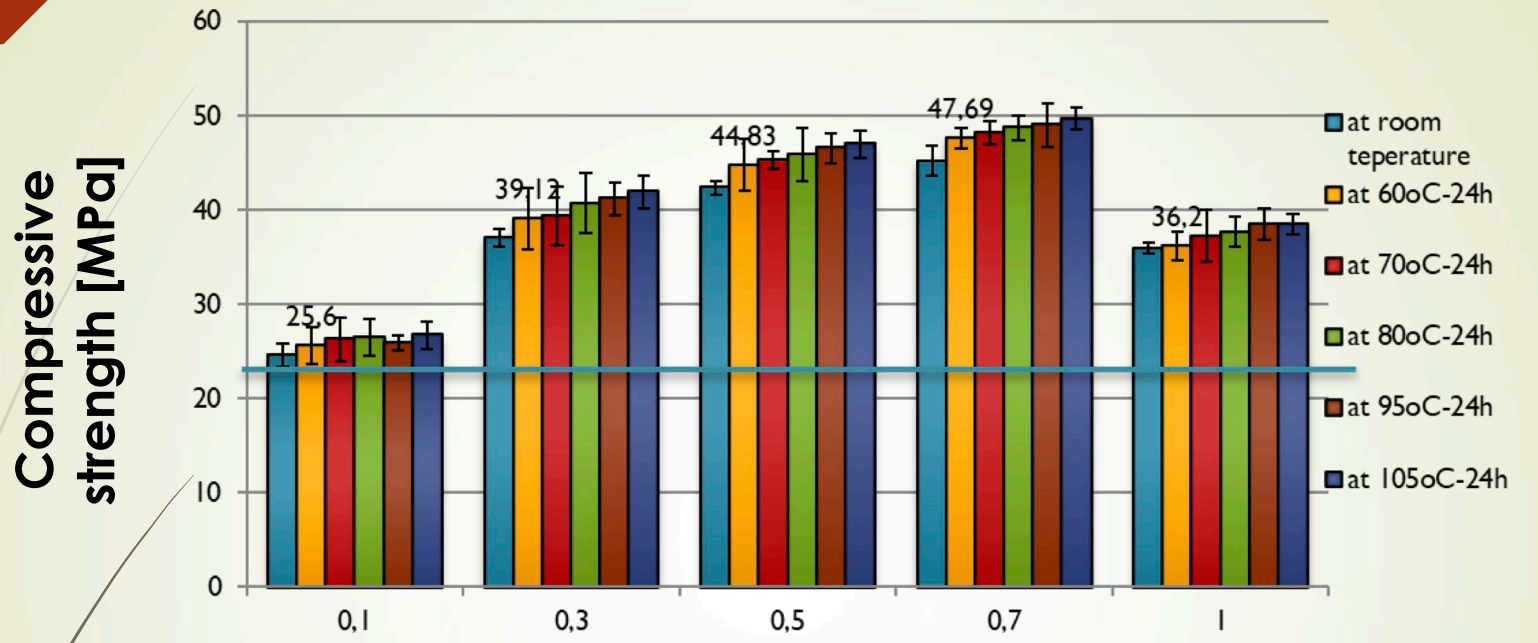
- *Modulus of elasticity:*

$E_m = 2707(\sqrt{R_m}) + 5300$ *(MPa)*

Preparation samples (photo by Linh.T.T)

Nanofibres SiO_2 reinforced geopolymer

– effect of curing temperature on mechanical properties



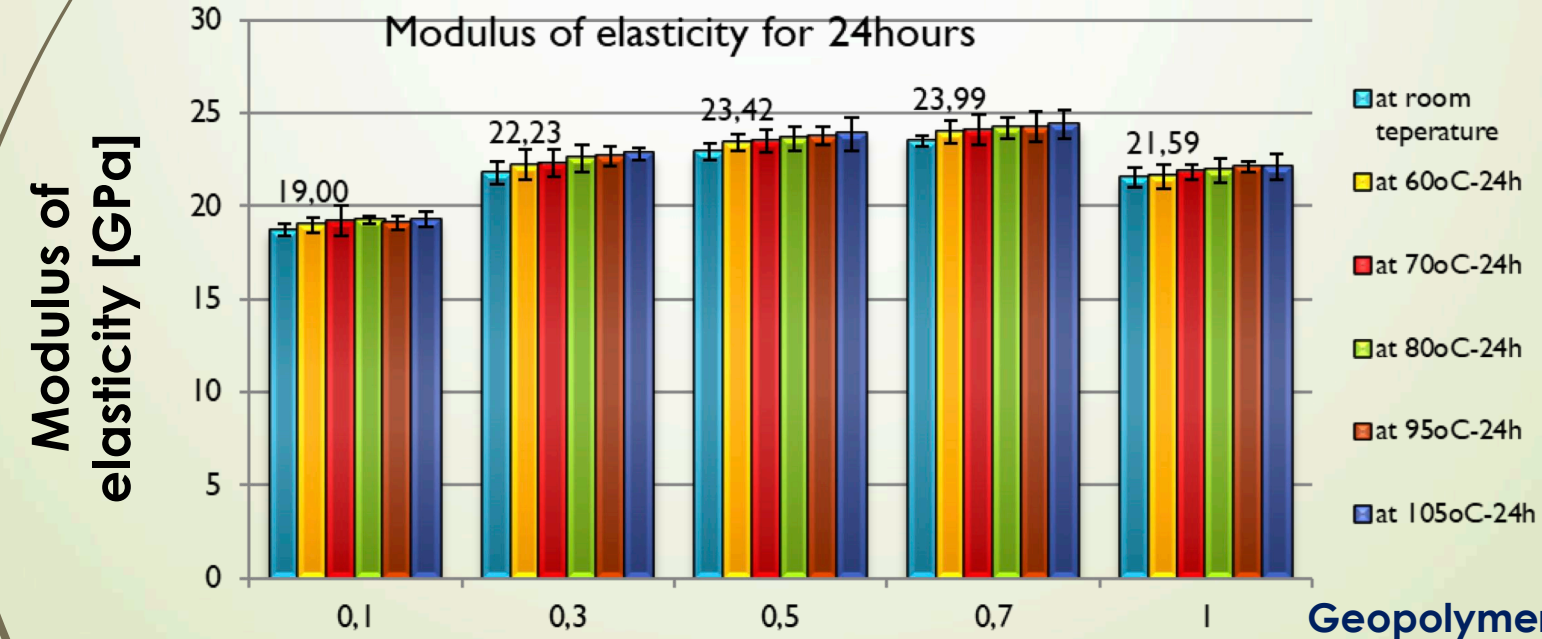


Table of compressive strength and modulus of elasticity of geopolymer reinforced fiber with curing at 60^0C for 24 hours

% (wt)	Carbon Fiber (µm)		% (wt)	Carbon Submicro Fiber		Nanofiber SiO_2	
	R_m (MPa)	Em (GPa)		Rm (MPa)	Em (GPa)	Rm (MPa)	Em (GPa)
1	**26.48** ±1.2	**19.23** ±0.32	0.1	**24.91** ± 1.34	**18.81**± 0.34	**25.6** ±1.95	**19** ±0.41
3	**27.95** ±0.72	**19.61** ±0.17	0.3	**37.07** ± 1.67	**21.78** ± 0.63	**39.12** ±3.2	**22.23** ±0.81
5	**31.16** ±0.42	**20.41** ±0.69	0.5	**38.96** ± 0.76	**22.20** ± 0.54	**44.83** ±2.73	**23.42** ±0.44
7	**33.57** ±1.23	**20.98** ±0.38	0.7	**39.81** ± 1.92	**22.38** ± 0.61	**47.69** ±1.08	**23.99** ±0.59
8	**42.37** ±1.17	**22.92** ±0.59	1	**36.92** ± 0.77	**21.75** ± 0.52	**36.2** ±1.55	**21.59** ±0.67
10	**29.54** ±2.1	**20.01** ±0.67					

Pure geopolymer

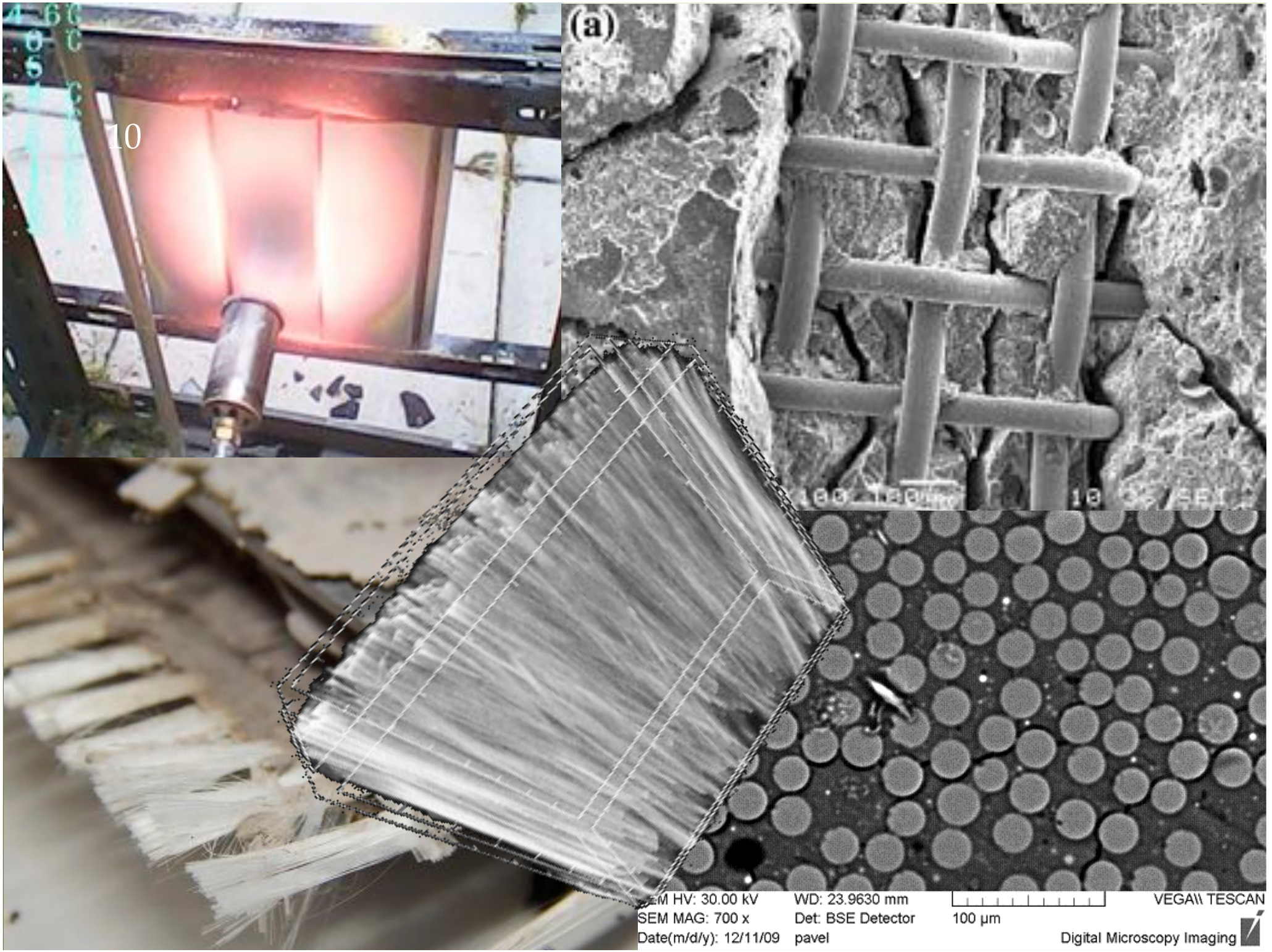
Rm = **25.36** ± 1.17 MPa

Em = **18.93** ± 0.59 GPa

Ordinary Portland cement

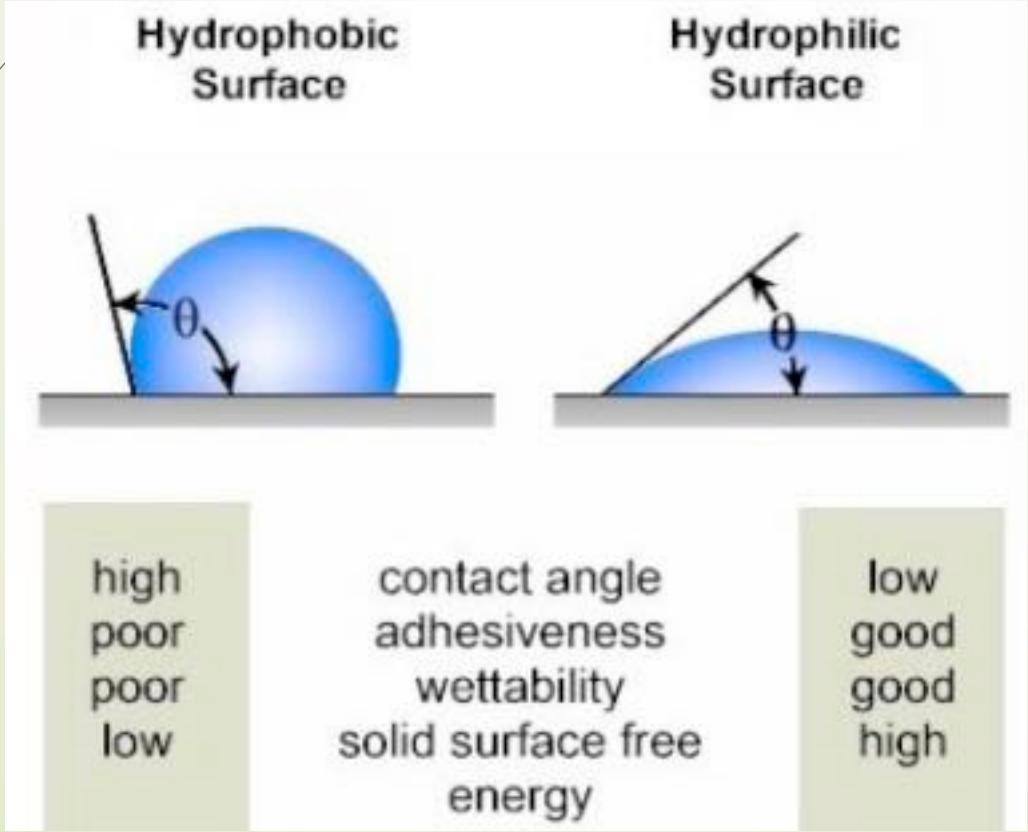
Rm = **17- 40** MPa

Em = **16.5- 22.4** GPa


10
(a)
SEM HV: 30.00 kV
SEM MAG: 700 x
Date(m/d/y): 12/11/09
WD: 23.9630 mm
Det: BSE Detector
pavel
100 µm
VEGA\\ TESCAN
Digital Microscopy Imaging

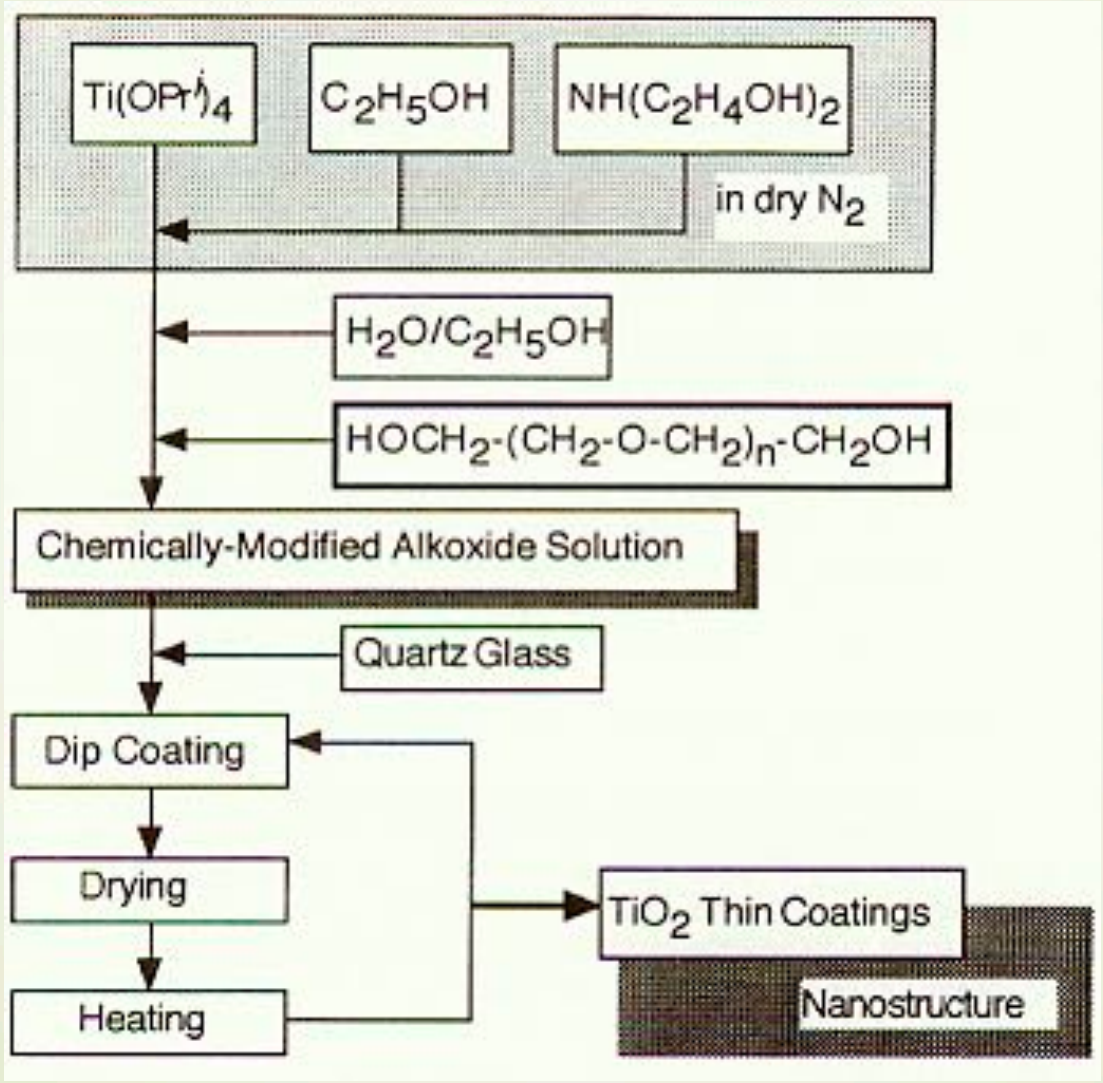
Hydrophobic treatment

- Sol-gel method
- Emulsion method **= Impregnating liquid**
- The methyl-silicon resin + xylene + NPs + NA?



Sol-gel method

Titanium tetra-iso-propoxide **Diethanolamine**



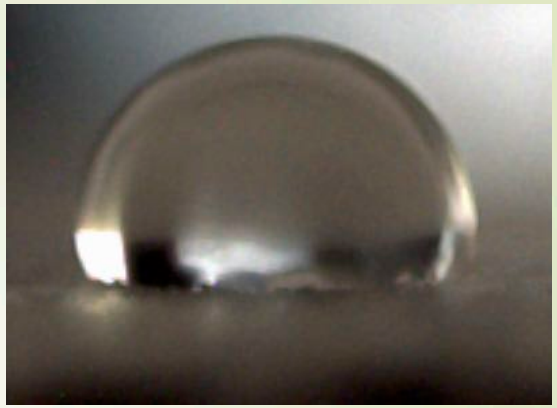
Polyethylene glycol

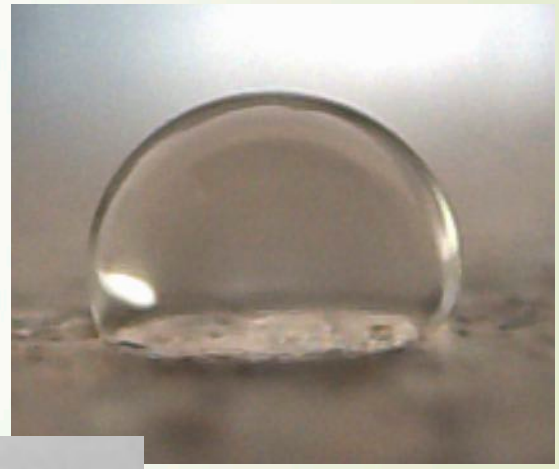
SiO_2 substrate

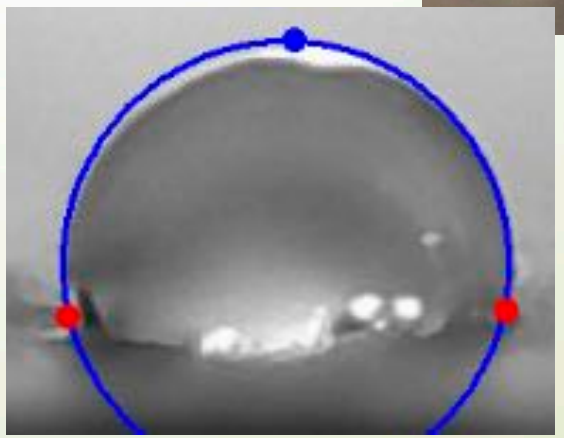
Solution I with Polyethylene glycol
Solution II without Polyethylene glycol

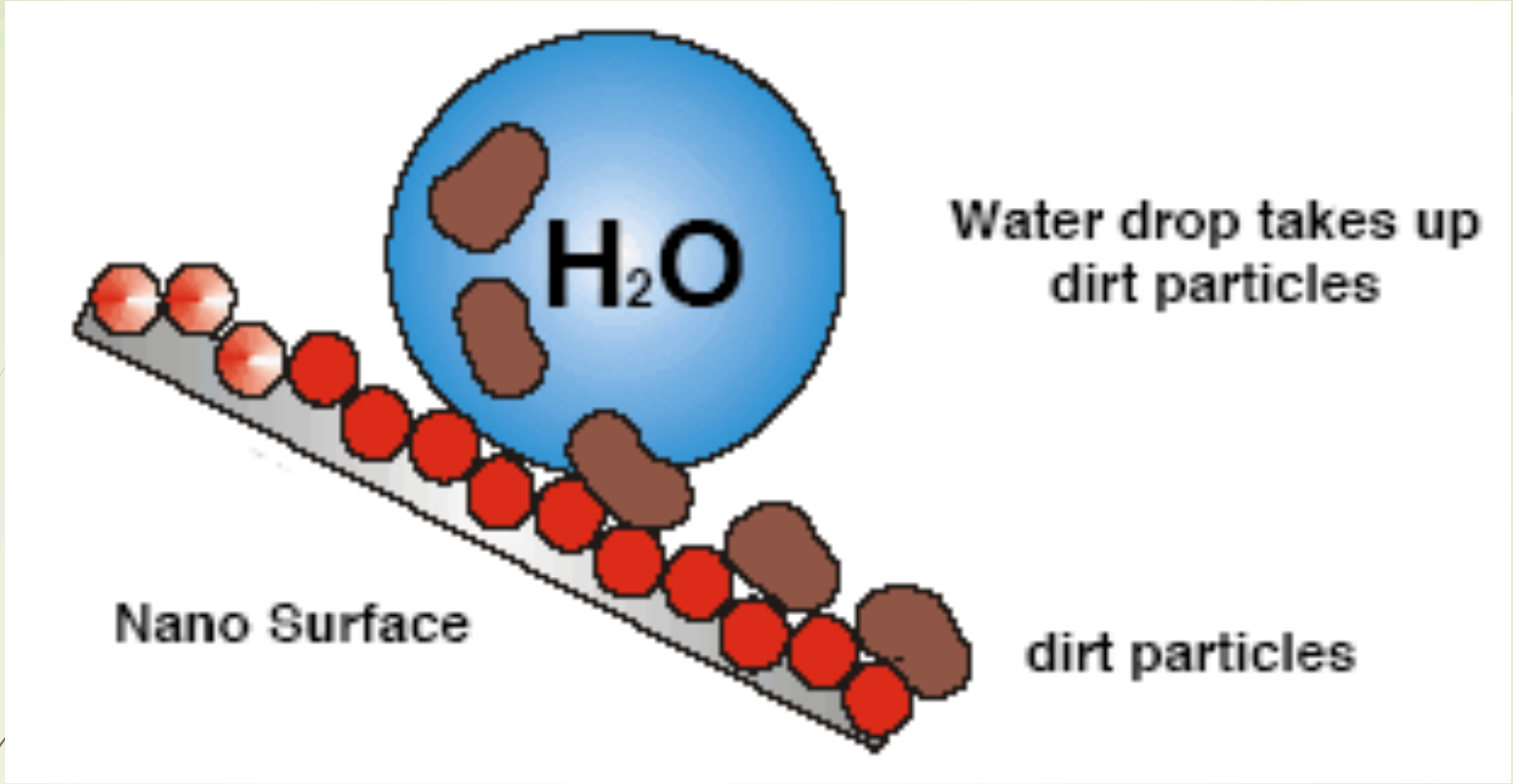
Contact Angle Measurements

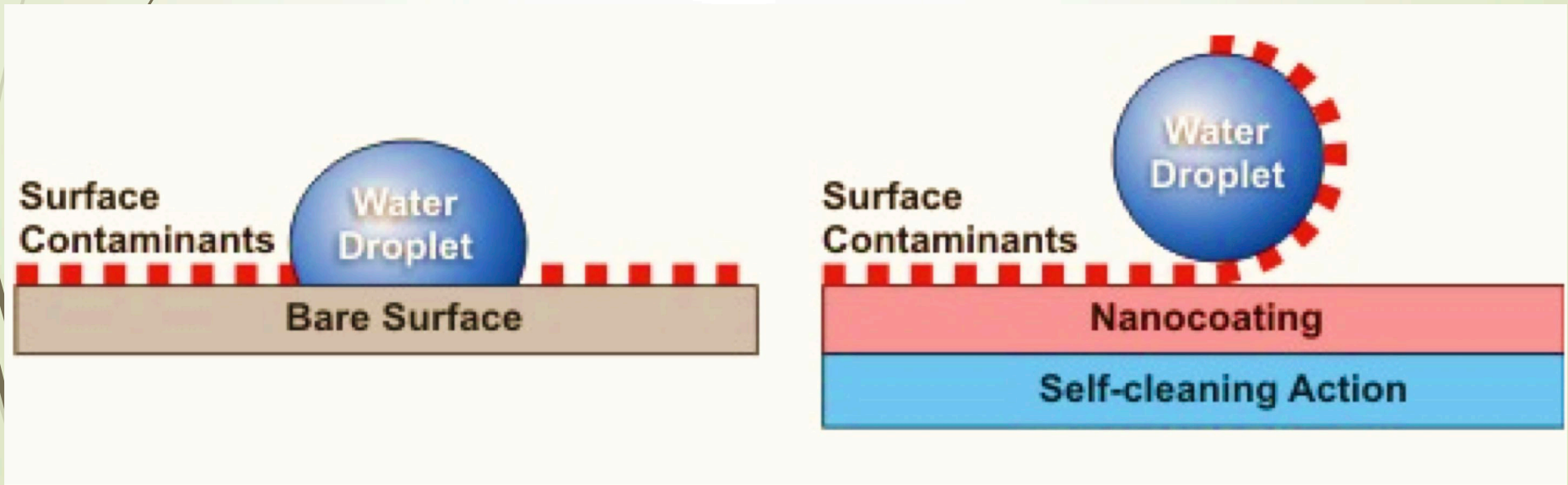
Sample	Θ [°]
Untreated	**47.64**
Pure emulsion	**103.18**
Emulsion with NPs	**105.39**
Sol-gel	**97.58**









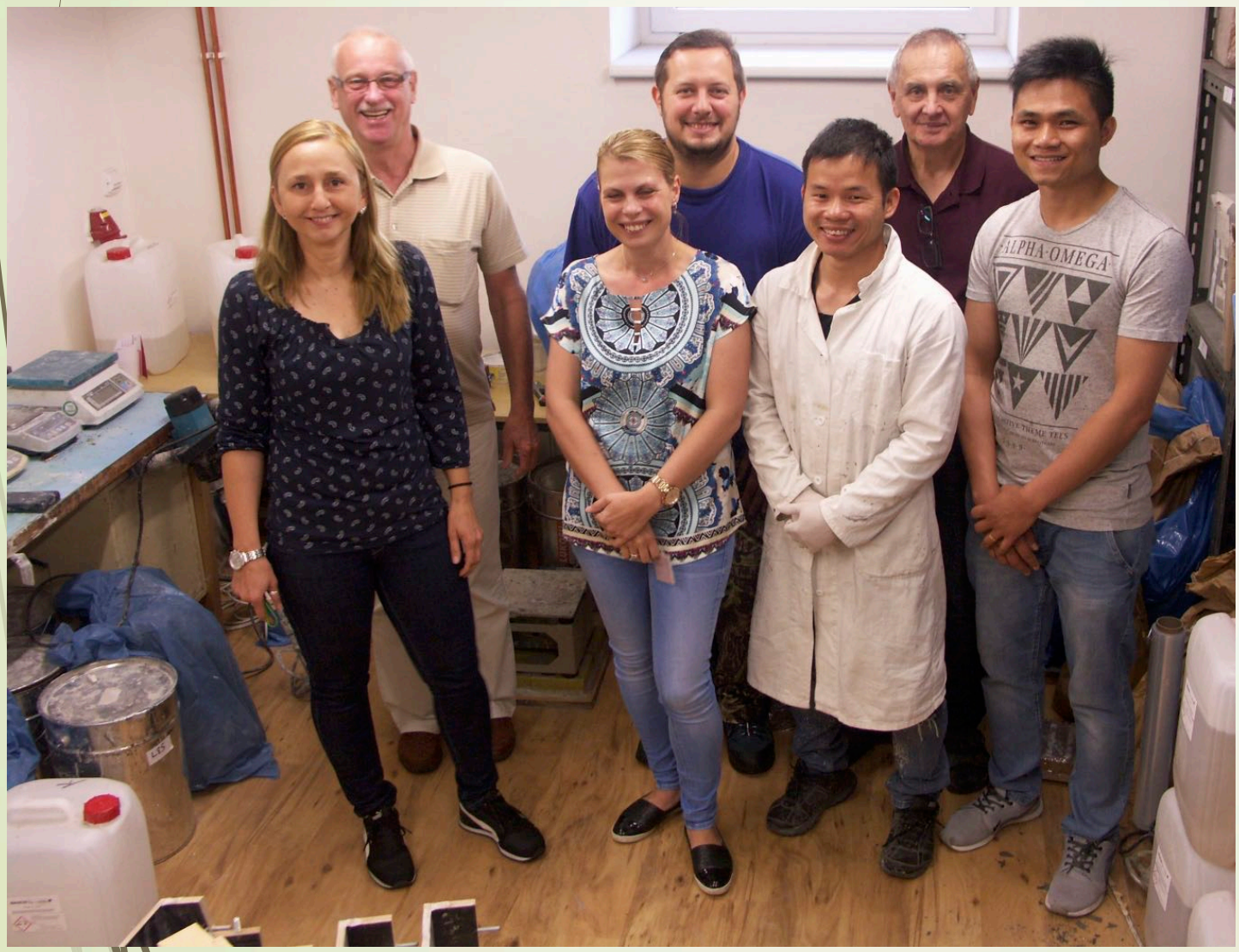


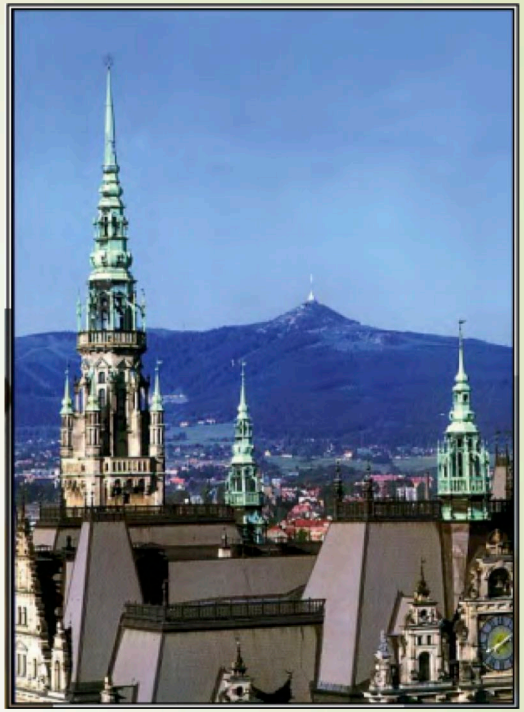
Self-cleaning effect

RESULTS

- Application of **nanomaterials** in GP **improves** utility **properties**.
- **Compressive strength** of **SiO_2 nano fiber reinforced** geopolymer is 2x higher than pure GP
- **Basalt and carbon** microfiber is applied because of **competitive cost.**
- **Surface treatment** of geopolymer composites by chemical means enables **improved properties** of these materials.

Thank you for Your attention





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