NEUTRONS MATTER, 7-8 November 2017
Villa Wolkonsky and Centro Fermi, Rome, Italy

NOTTINGHAM TRENT UNIVERSITY

Better understanding of self-cross linking behaviour of smectite clays through VESUVIO

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NEUTRONS MATTER

The matter of neutrons?

Do neutrons matter?

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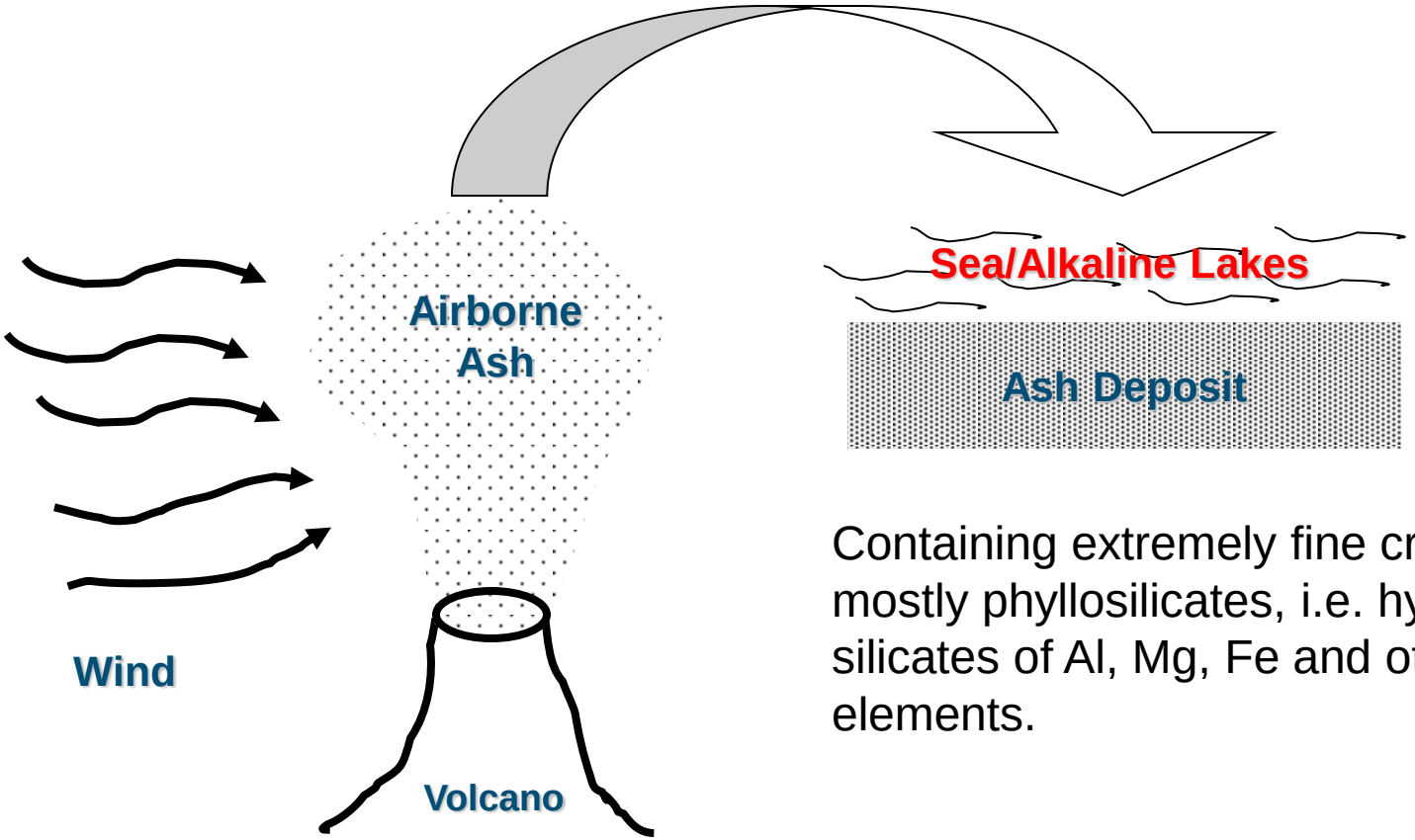
CLAY

ORIGIN

Hydrothermal alteration of alkaline volcanic ash and rocks of the Cretaceous period (85-125 millions years ago)



Containing extremely fine crystals mostly phyllosilicates, i.e. hydrous silicates of Al, Mg, Fe and other elements.

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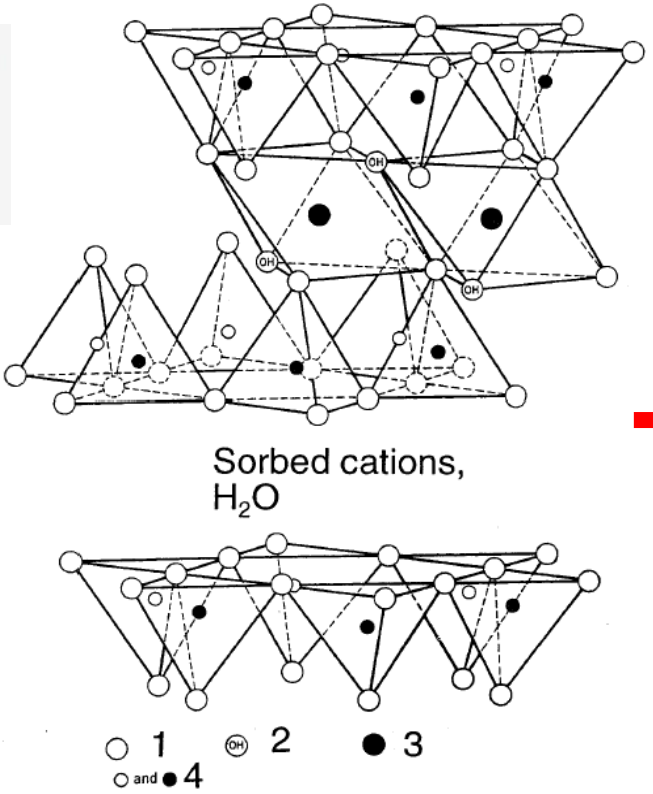
THE STRUCTURE OF SECTITE CLAY



One clay particle in micro-scale

1- oxygen, 2- hydroxyl,
3- aluminium or magnesium, 4-silicon

The crystal structure

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ULTRA-LIGHT WEIGHT MATERIALS

Graphene Based
Ultra Light Material
Produced at NTU

Gao & Carr, 2014

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ULTRA-LIGHT WEIGHT THERMAL RESISTANCE MATERIALS

Beesley and Gao, 2015

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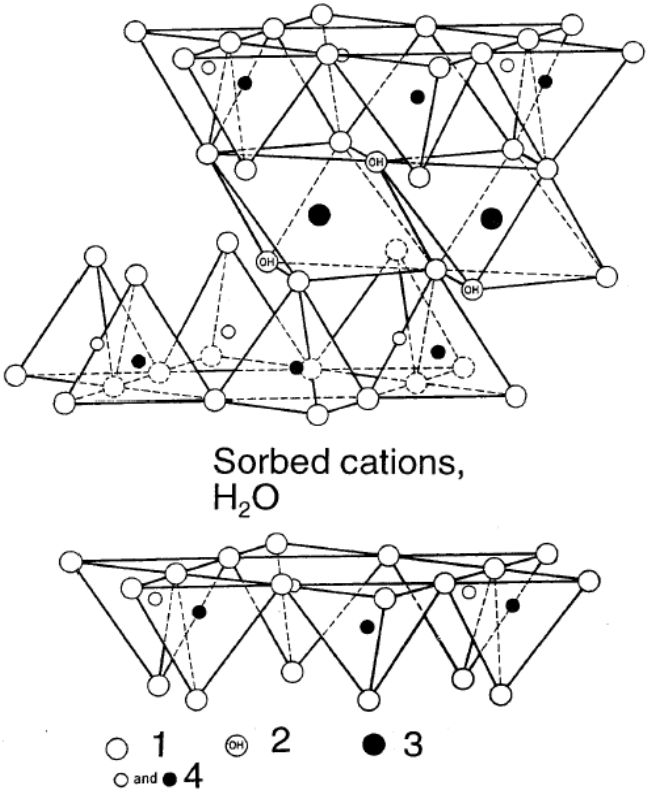
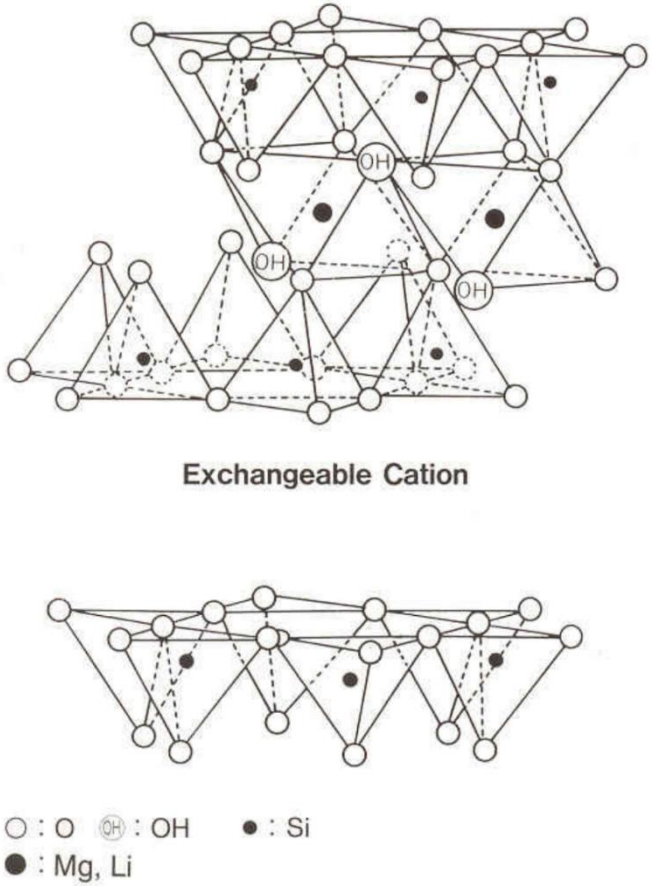


1- oxygen, 2- hydroxyl,
3- aluminium or magnesium, 4-silicon

Cloisite Na+
Natural montmorrilonite



SWN
Synthetic hectorite

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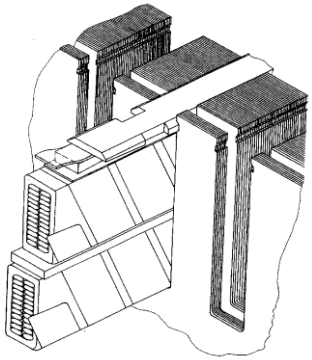
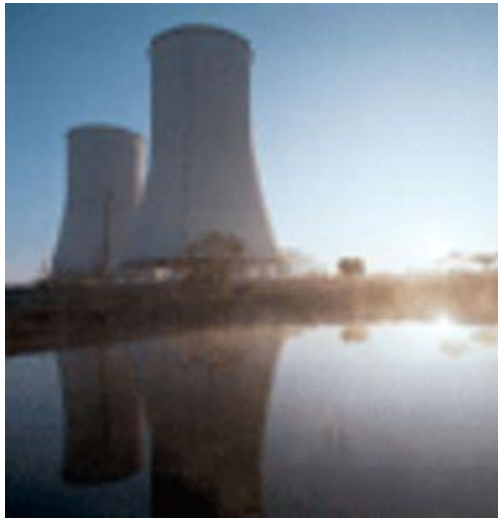
Clay/Polymer Nanotechnology for Energy Application

Mica tape



Stator slot

Steam turbine



Power plant

Sponsor: EU FP7

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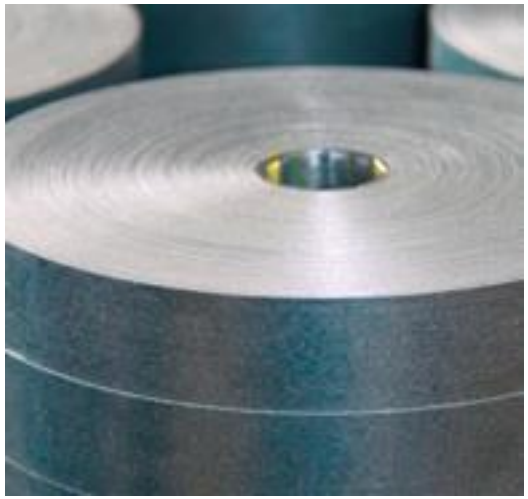
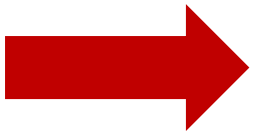
The role of dielectric tape in rotator generator





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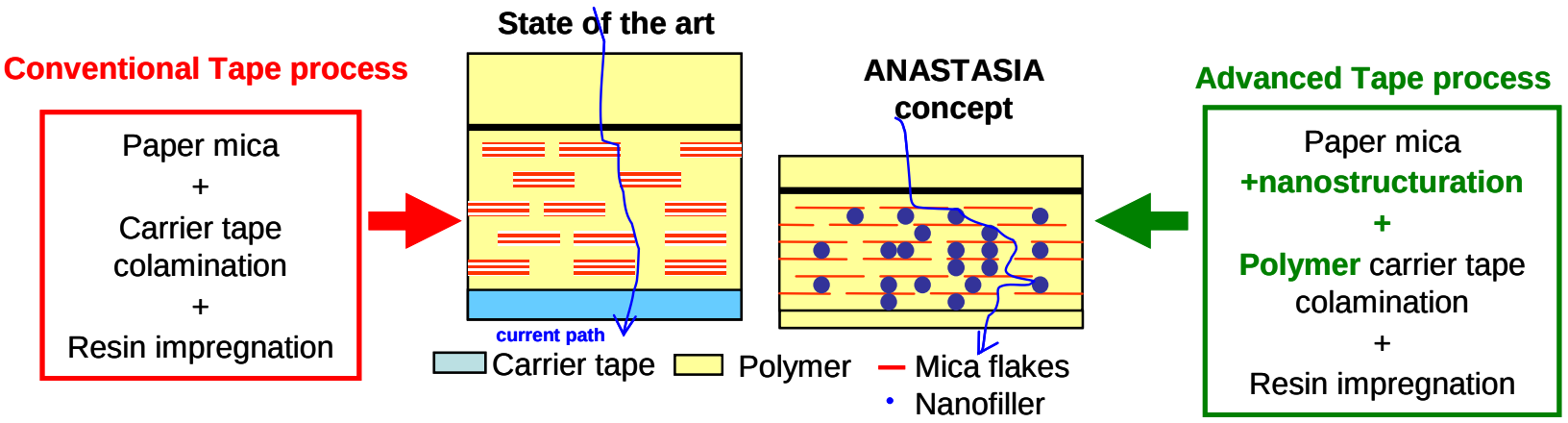
Clay/Polymer Nanotechnology for Energy Application

New generation nano-structured dielectric tape for power generation is being developed under the sponsor of EU FP7. Even for a small efficiency increase (+0,2%) the expected benefit represents a very substantial energy saving. At the European scale, a +0.2% gain in generator conversion efficiency could save the equivalent of one nuclear power plant of 1000 MW (1.5 billions €) or nearly 10 fossil fuel power plants and related reduction in CO_2 emission.



HV insulating tape concepts and process

Sponsor: EU FP7

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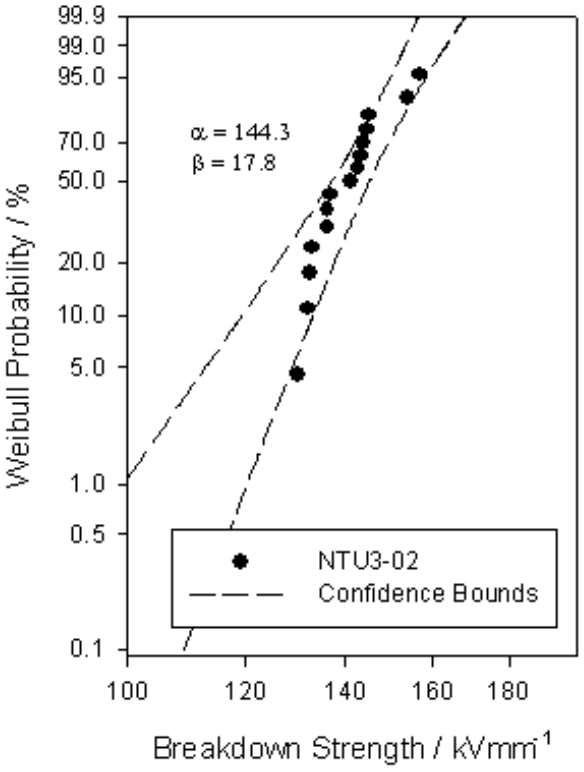
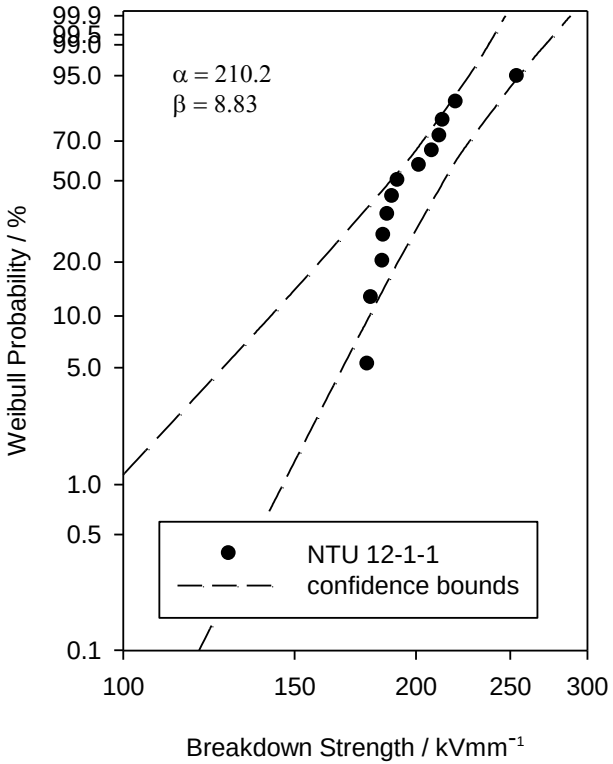
Clay/Epoxy Nanocomposite System

Breakdown Strength (100μ thick sample)



The original resin



2wt% of organoclay

Gao, Nigmatullin, Thompson 2012

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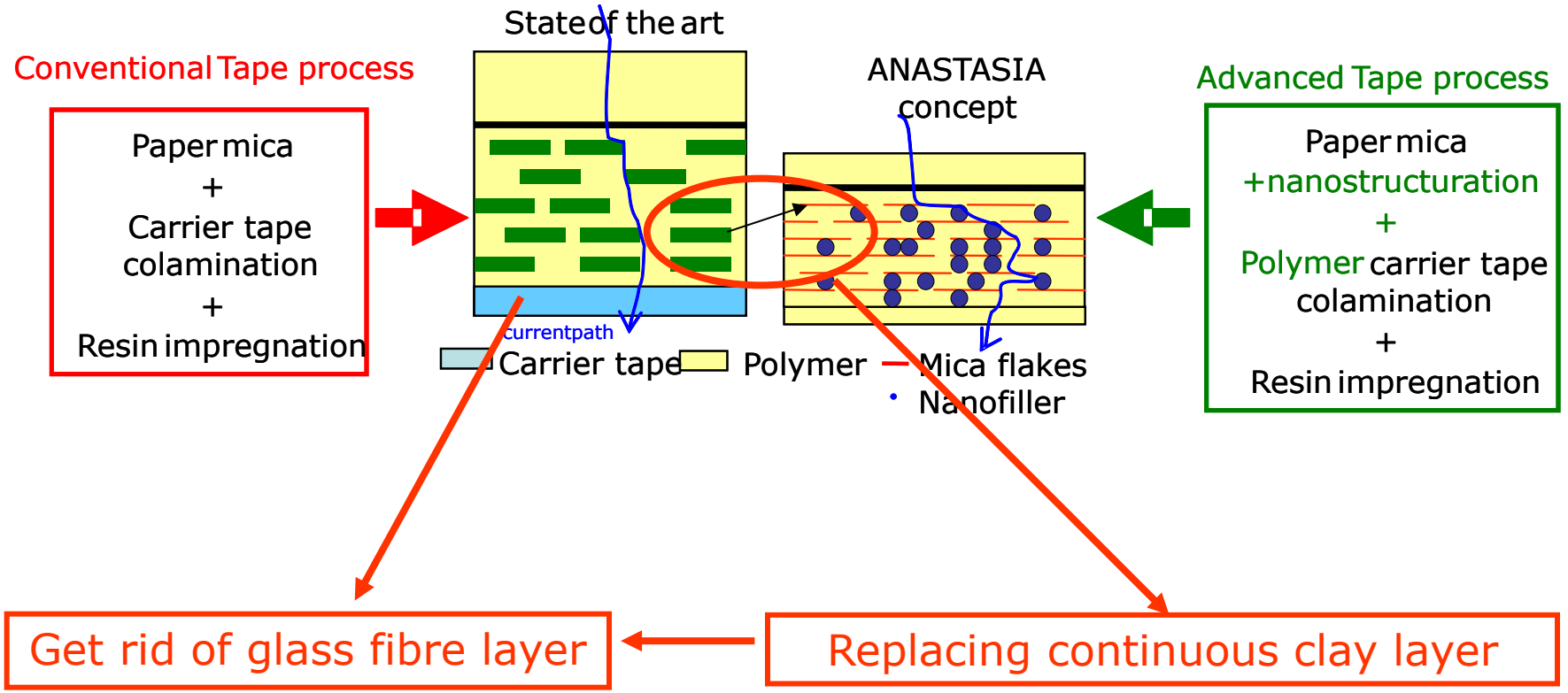
Clay/Polymer Nanotechnology for Energy Application



Our new gel coating technology

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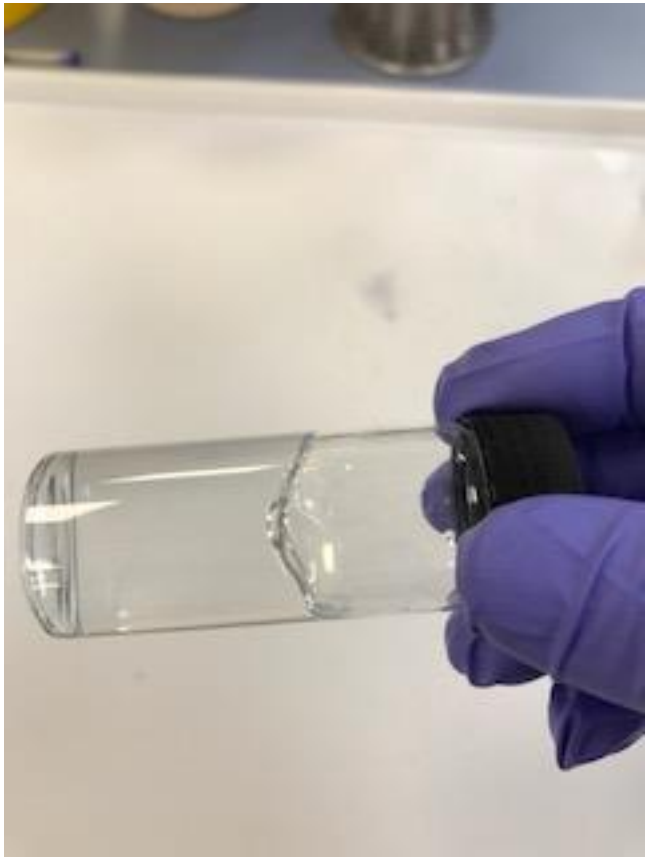
Self cross linking behaviour of two clays at 3wt% aqueous suspension

Cloisite Na+
Natural montmorrilonite



SWN
Synthetic hectorite

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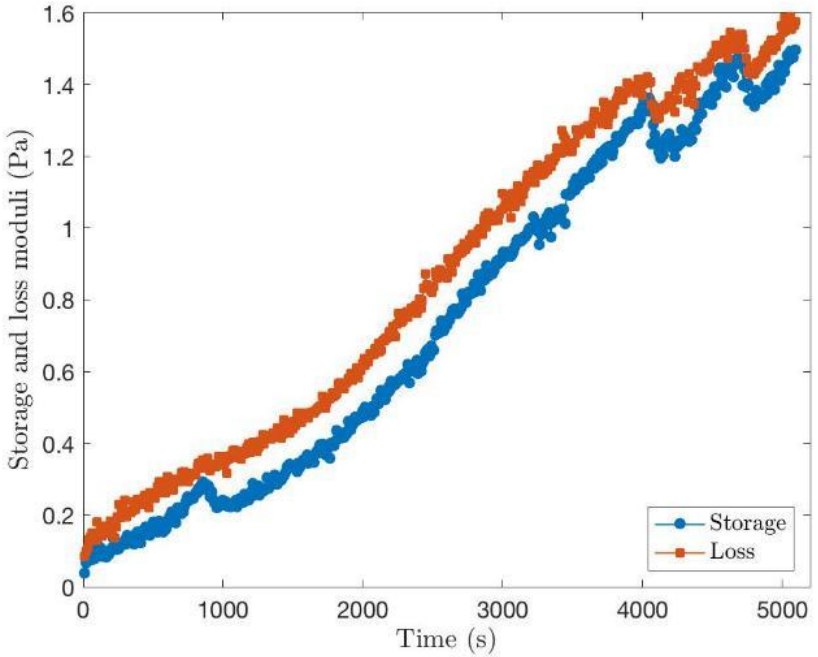
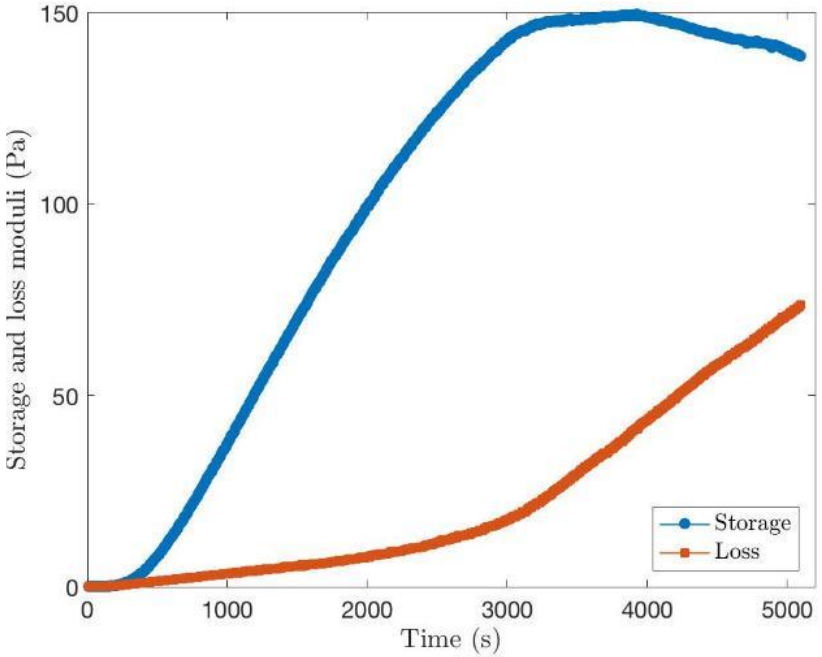
3wt% clay suspension, oscillation frequency 0.5Hz, strain 0.05





Cloisite Na+
Natural montmorrilonite

SWN
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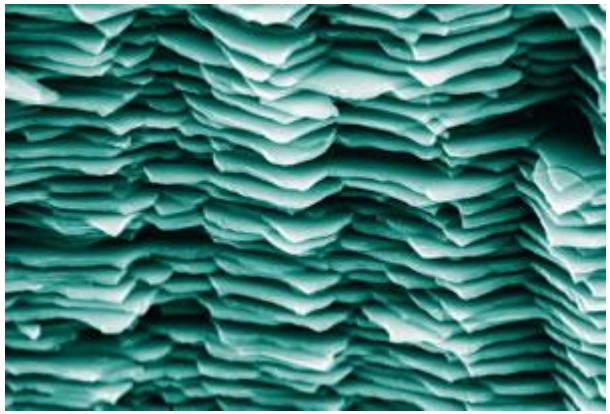
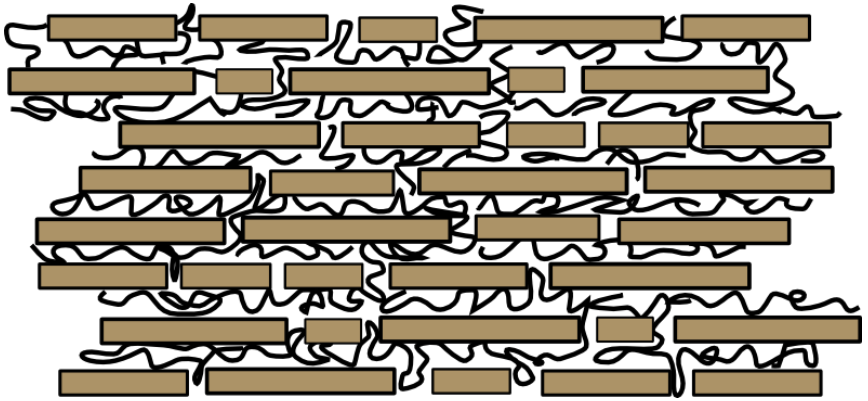
Nacre-like Materials produced by Clay with BC





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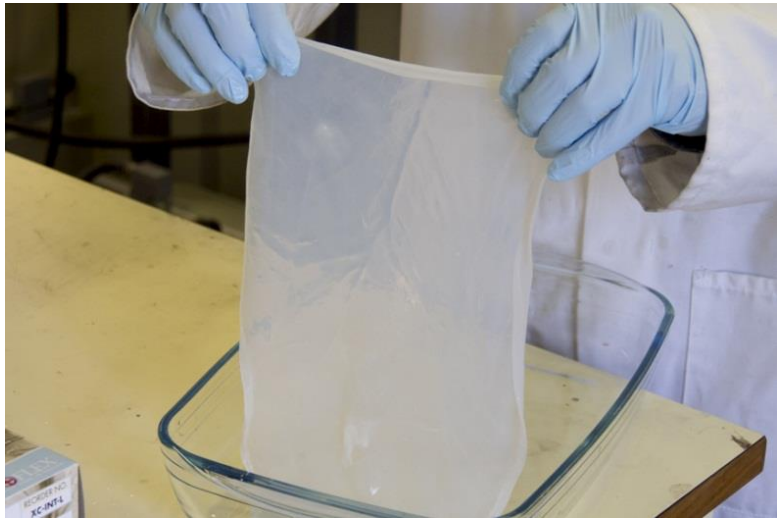
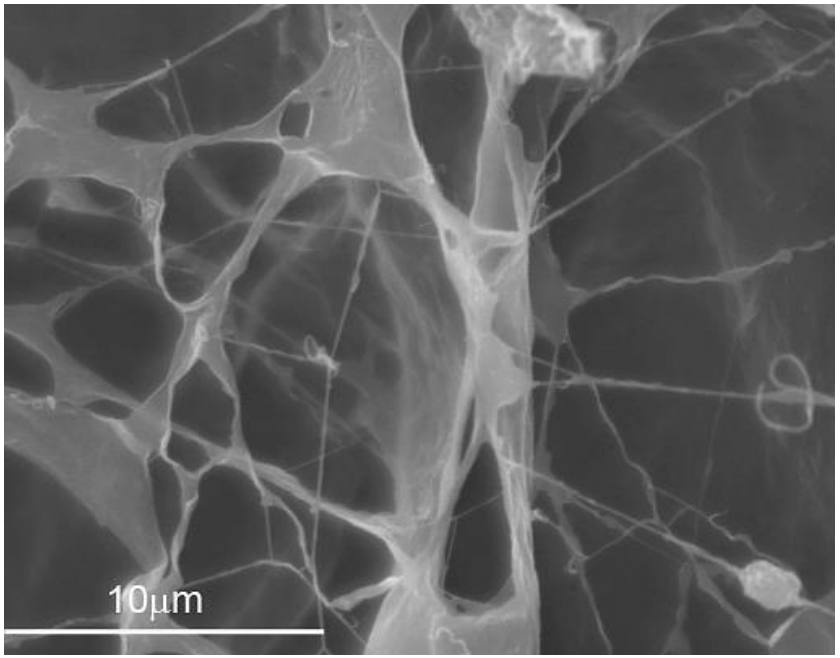
Nacre-like Materials produced by Clay with BC





Growth only occurs in Cloisite Na+ but not SWN

Gao & Loughlin, 2013

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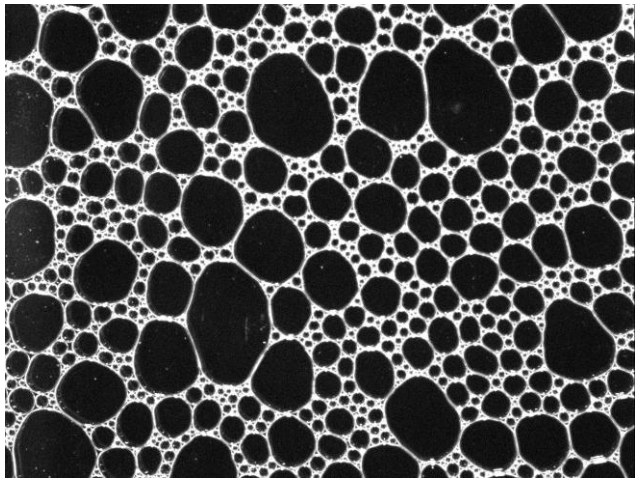
The use of clay to improve foam stability



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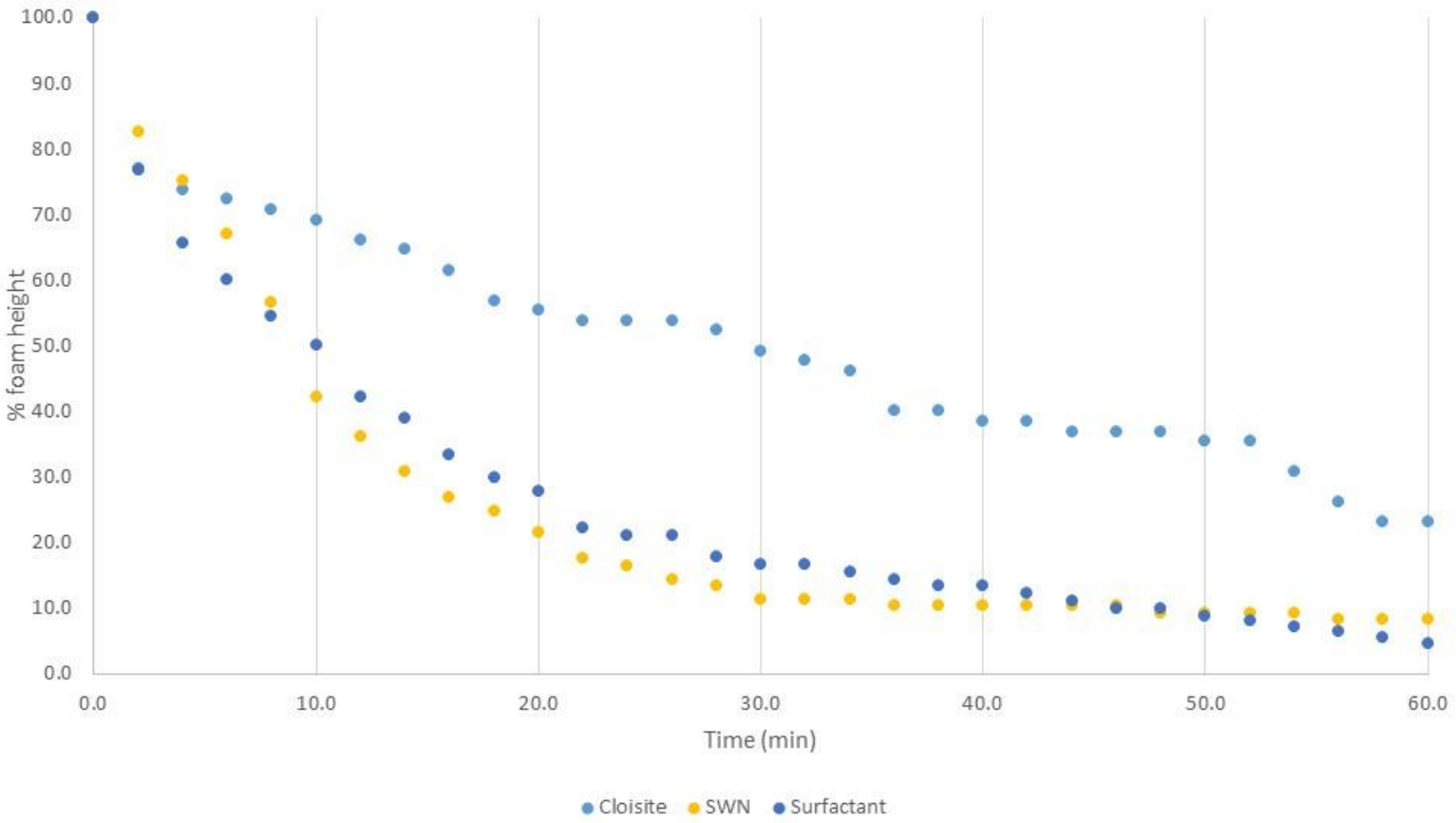
The use of clay to improve foam stability
Adding 0.5wt% clay



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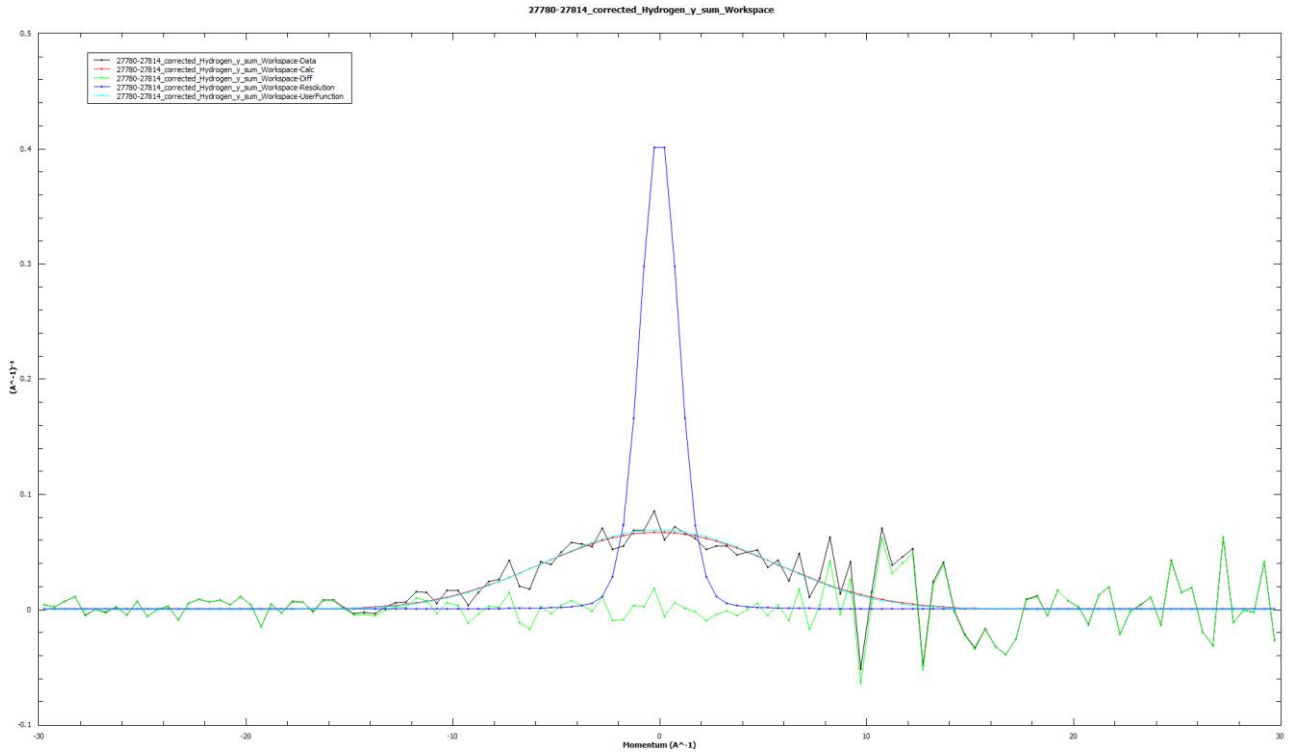
Cloisite Na^+ in dried state

Hydrogen momentum distribution



Standard deviation = 5.0 +/- 0.3
Kurtosis = -0.1 +/- 0.1

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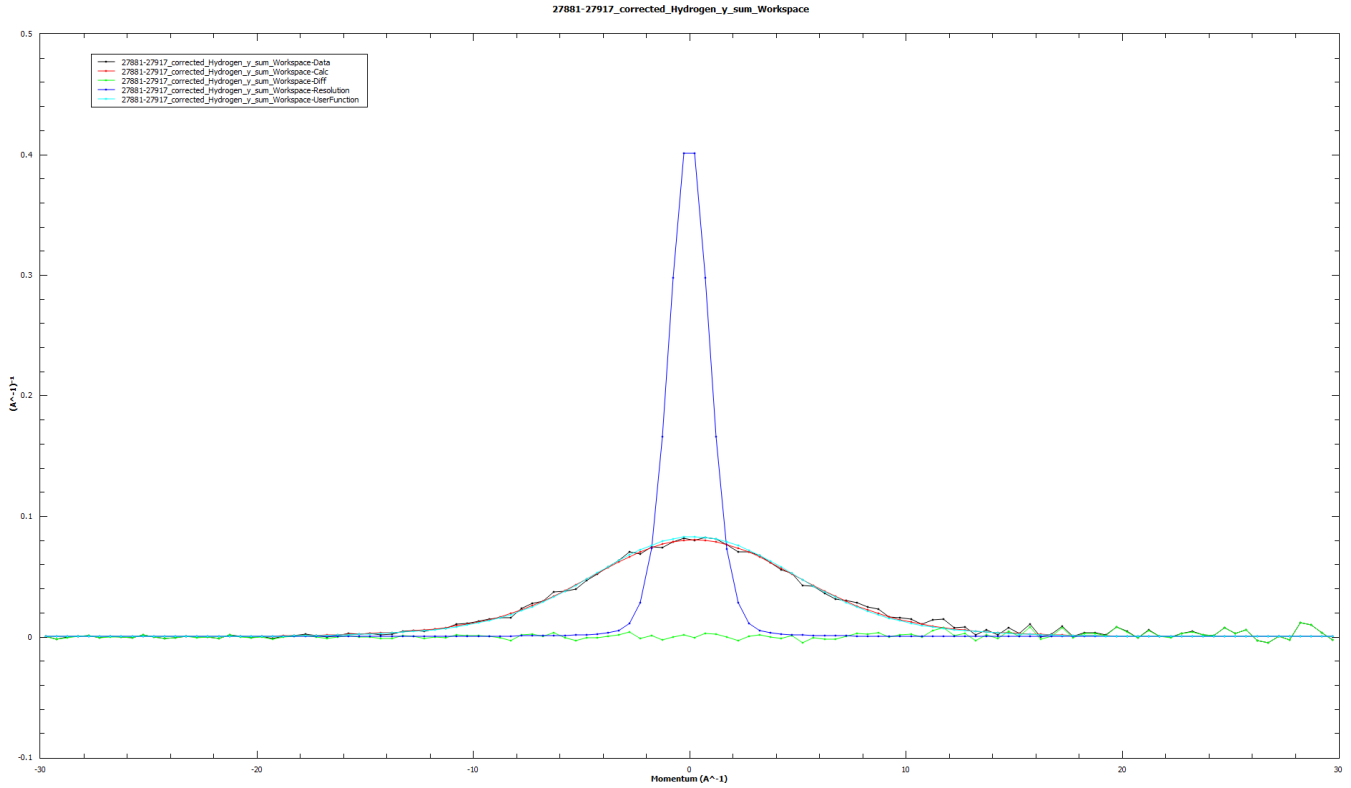
3wt% Cloisite Na^+ in water suspension

Hydrogen momentum distribution



Standard deviation = 5.35 +/- 0.08

Kurtosis = 0.23 +/- 0.03

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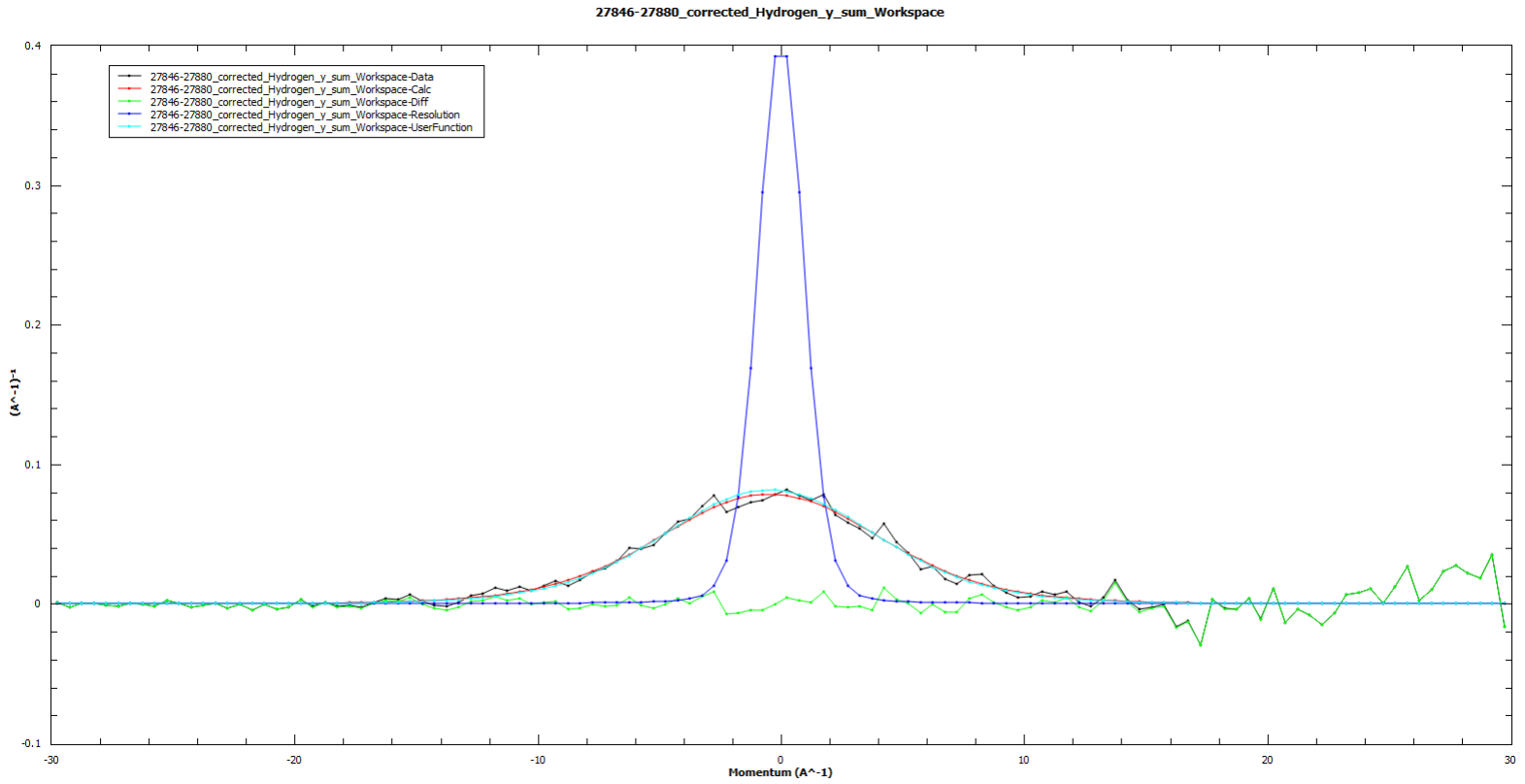
SWN in dried state

Hydrogen momentum distribution



f1.standard deviation = 4.92 +/- 0.12
f1.kurtosis = 0.20 +/- 0.06

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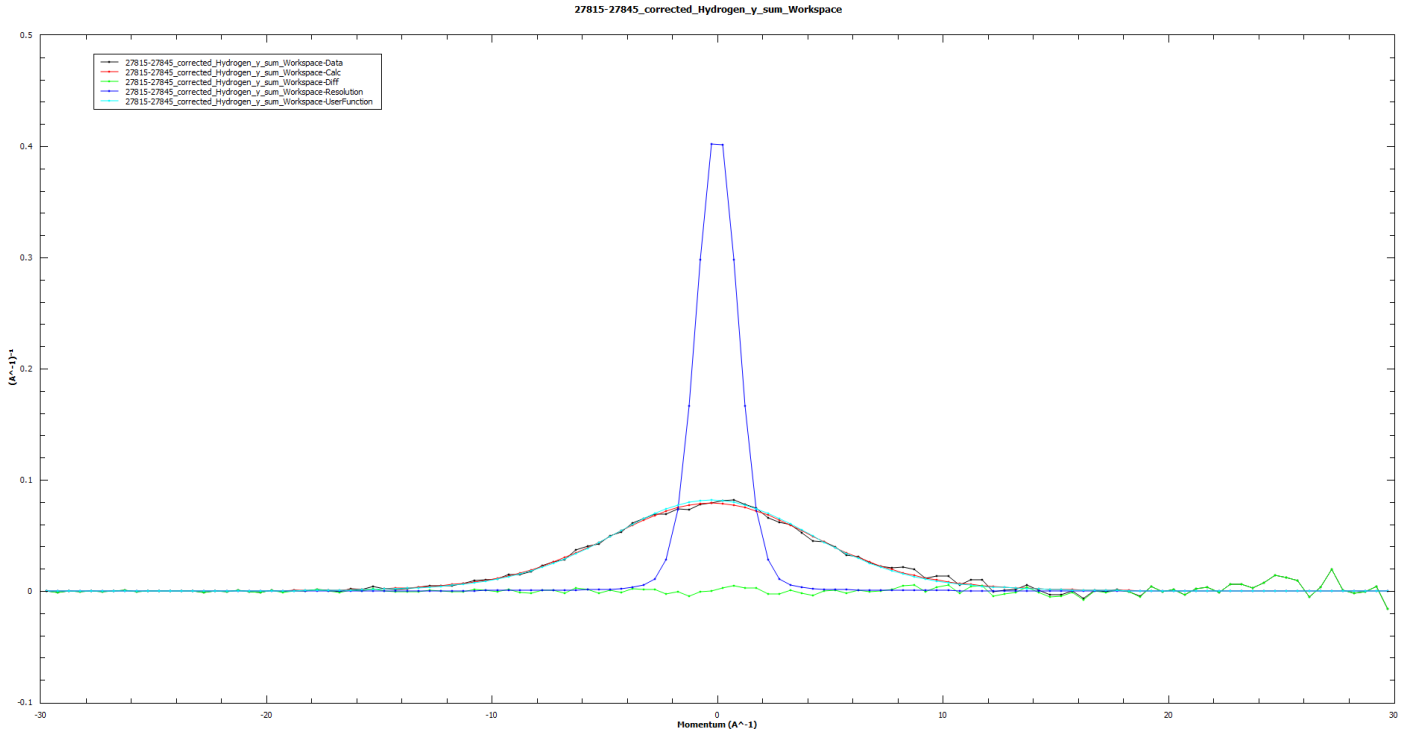
3wt% SWN in water suspension

Hydrogen momentum distribution



f1.standard deviation 4.97 +/- 0.05

f1.kurtosis 0.19 +/- 0.02

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A very surprise result

- Pure water hydrogen momentum distribution is 4.76 ± 0.035. In both dry and 3wt% Cloisite hydrogen is more bound (the width of hydrogen momentum distributions are both higher than in bulk water).

- In water suspension, hydrogen is more bounded in Cloisite Na+ situation. SWN gives less effect of hydrogen momentum distribution in water.

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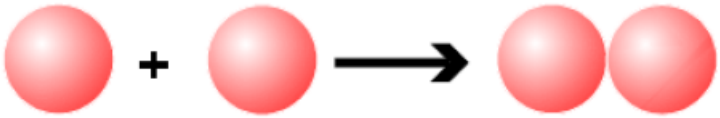
Strength of interparticle forces – Rates of coagulation



$$A + A \rightarrow A_2$$

$$\frac{dN_2}{dt} = \frac{k}{2} N_1^2$$

k is the aggregation rate coefficient

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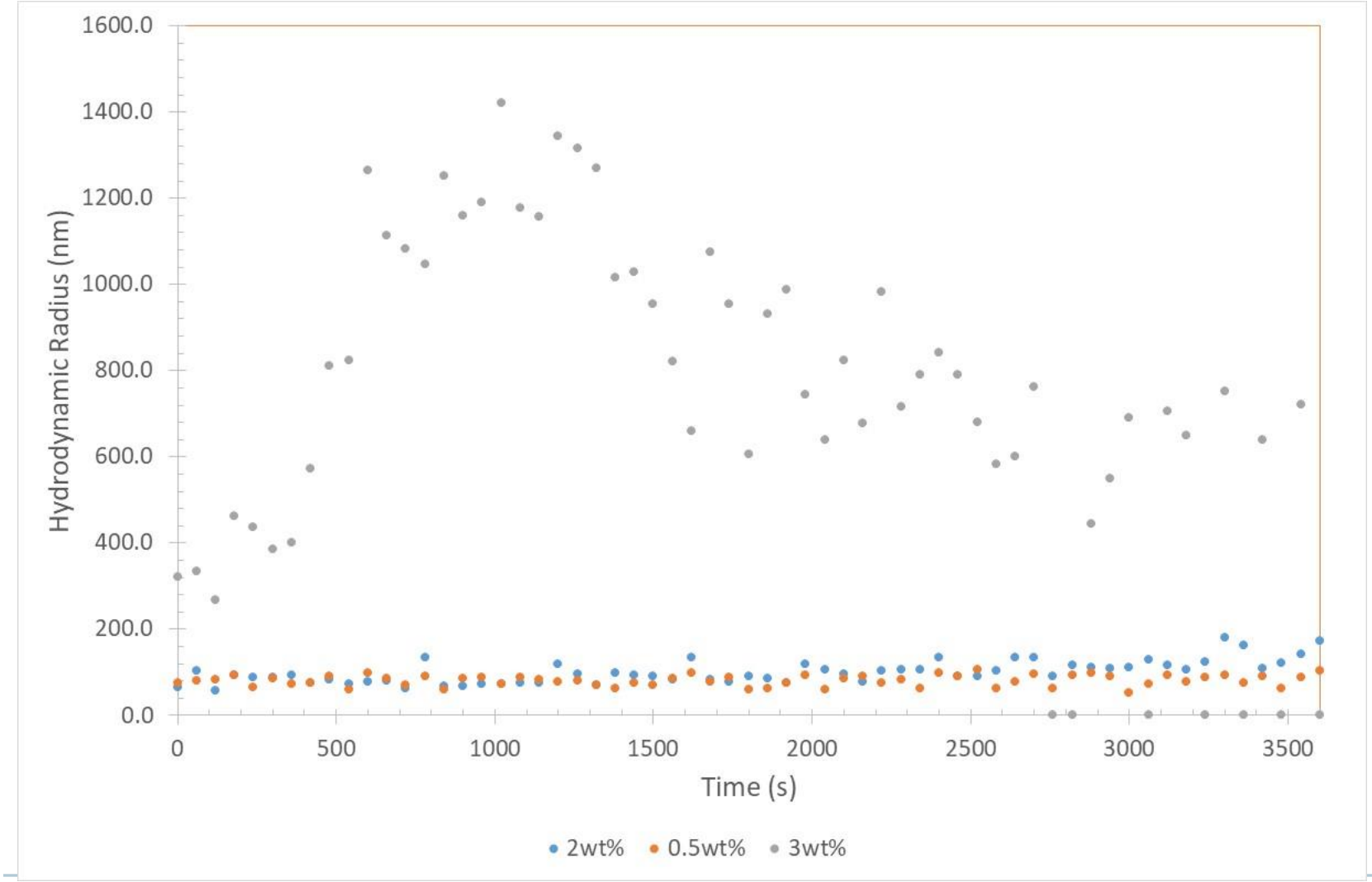
Hydrodynamic radius of SWN in different concentration as a function of time, DLS



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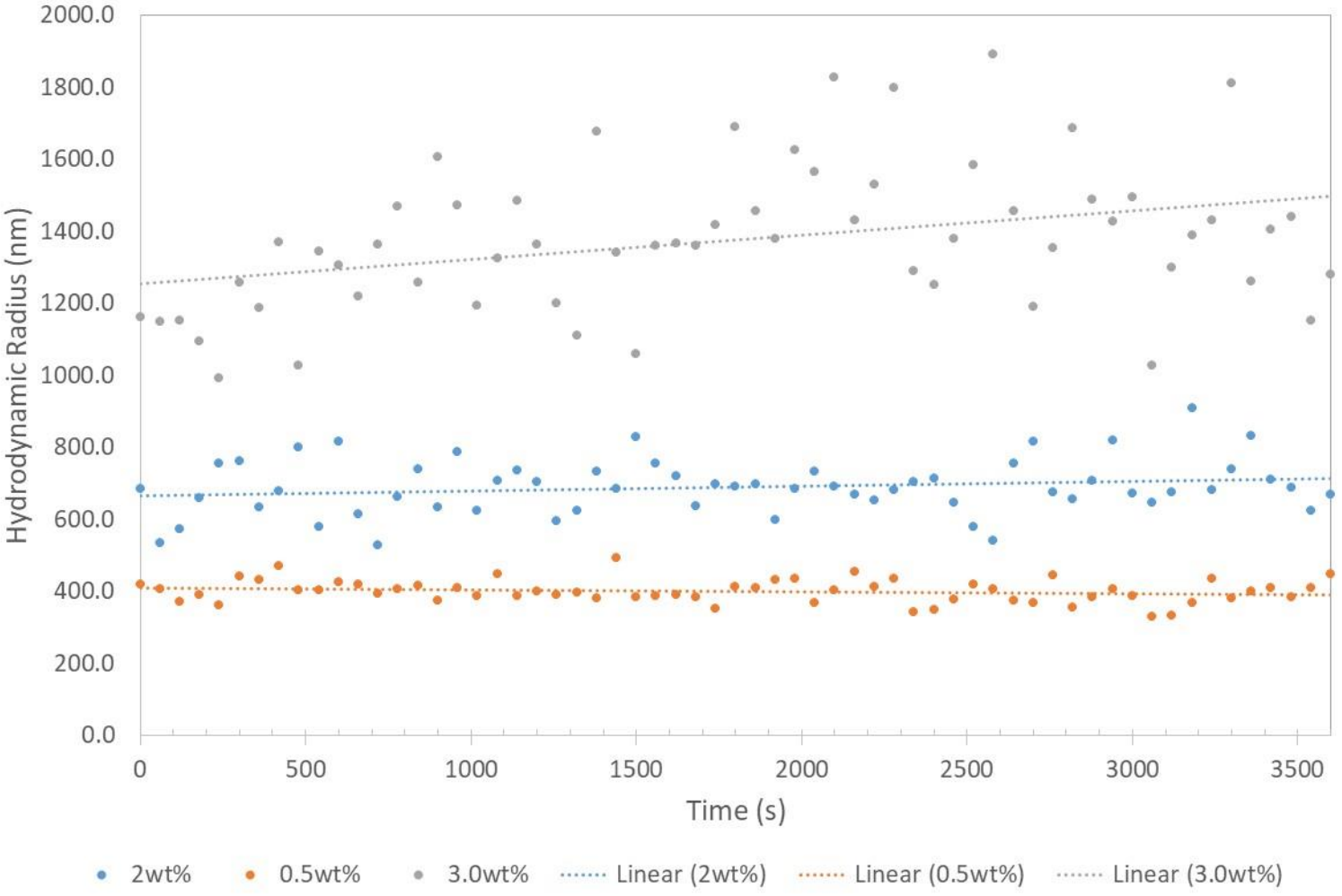
Hydrodynamic radius of Cloisite Na+ in different concentration as a function of time, DLS



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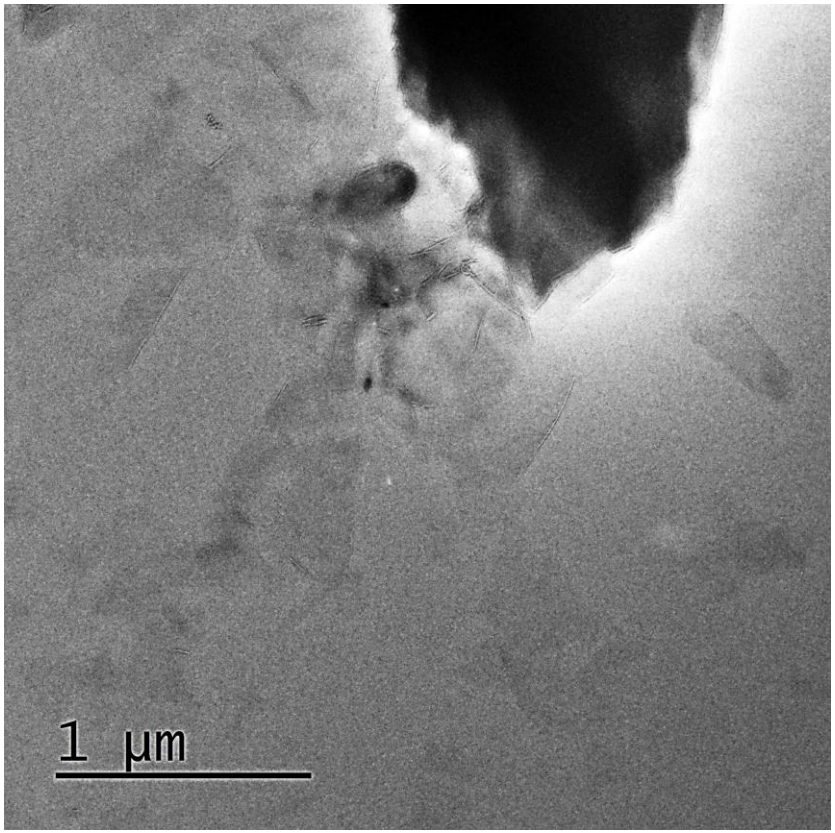
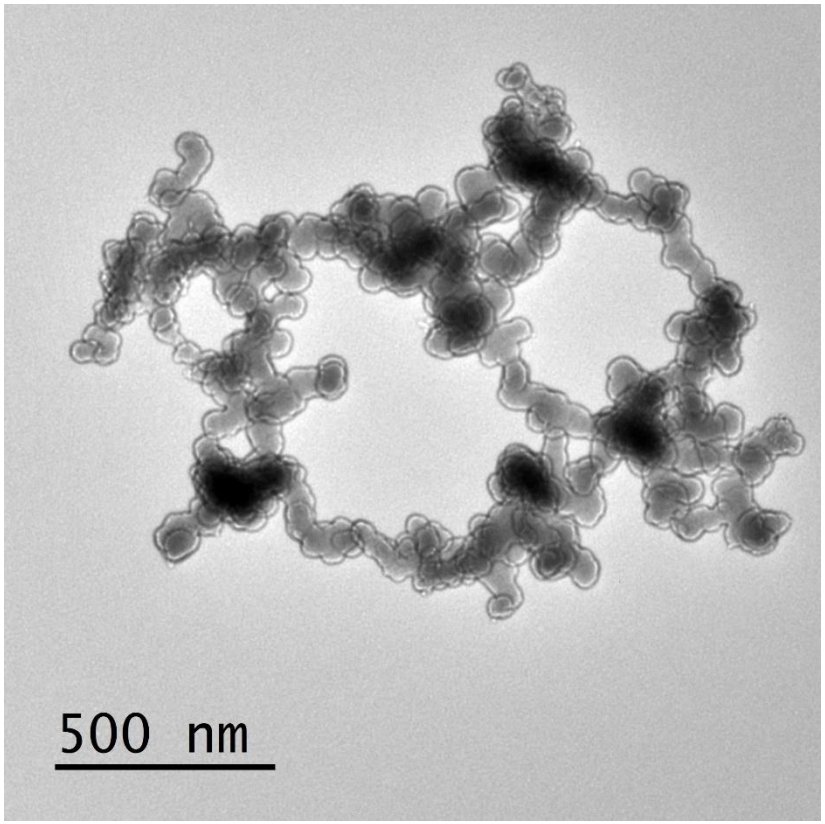
A drop of low clay concentration clay suspension on TEM grids



Cloisite Na+
Natural montmorrilonite



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Synthetic hectorite

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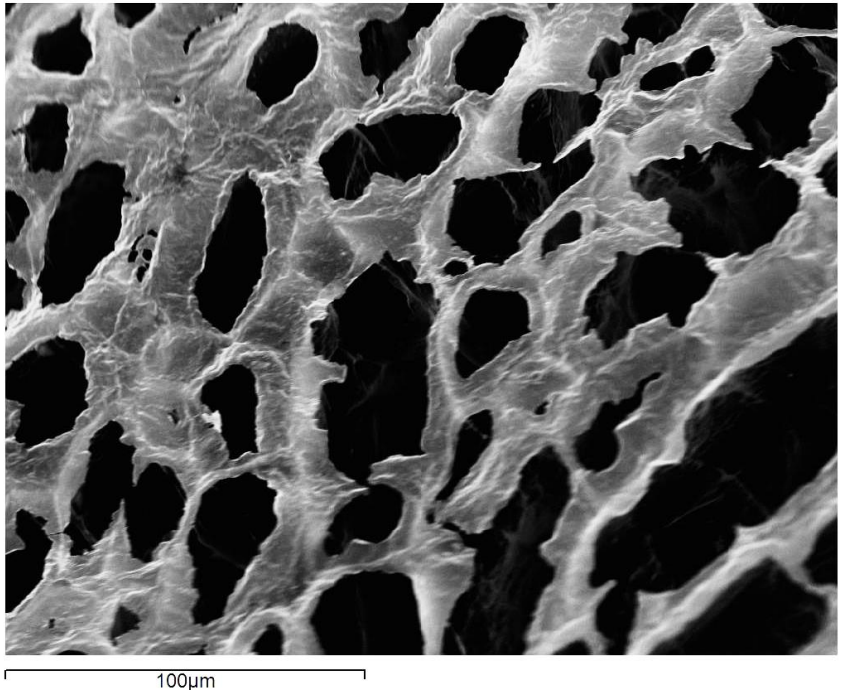
SEM micrograph of freeze dried clay suspension with 3wt% clay



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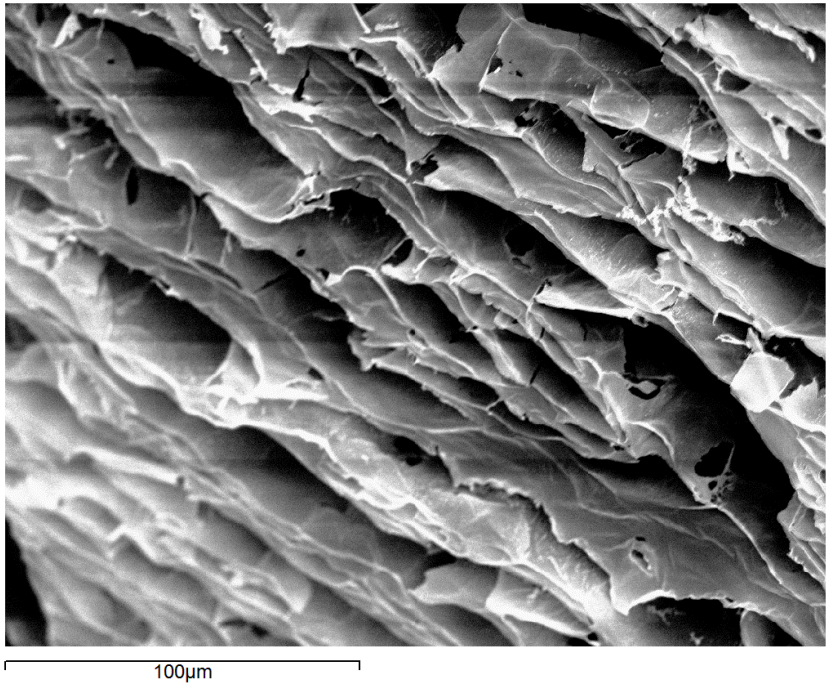

SWN
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WHAT MATTERS TO APPLICATIONS?

- VESUVIO study showed rapid self cross-linking behaviour of SWN clay. The interaction is confined to clay particle themselves with limited effect on water. This situation may not be ideal for gel coating application due to lack of control of homogeneity of the gel. Cloisite Na^+ has potential to be better if higher concentration of clay is applied.

- This investigation explained the reason behind lack of growth of BC in SWN. Self cross-linking of the clay increased the defusing resistance of air into the growth media, preventing bacterial propagation.

- Lack of interaction with surrounding environment in SWN leading to less effective in improving foam stability. In contrast, Cloisite Na^+ clay is well integrated into foam system to form more stable foam.

Neutron does matter!!!

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