

Preparation and comparison of polyurethane nano composite

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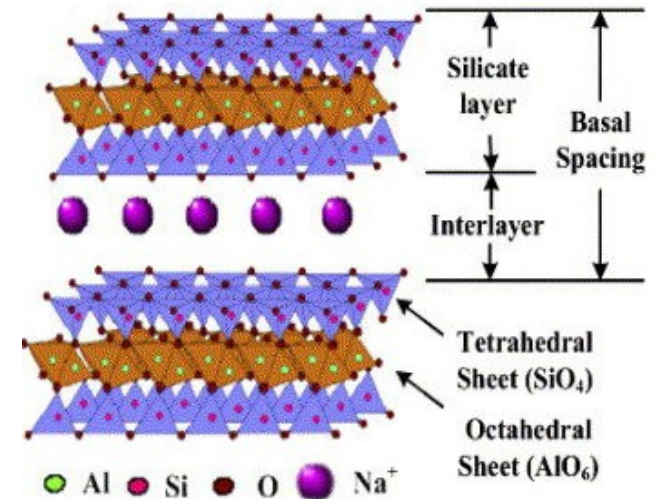
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Introduction

Polymer nano composite

- **Definition** : Polymers (thermoplastics, thermosets or elastomers) that have been reinforced with small quantities (less than 5% by weight) of nano-sized particles having high aspect ratios ($L/h > 300$).
- Mechanical and other functional properties of the polymer nanocomposite is a function of
 - Geometry (layered , platelets, cylindrical, spherical) ,
 - Nanoparticle orientation,
 - Type of functional groups
 - Coupling agents,
 - Molecular weight of the polymer chain
 - Interfacial properties

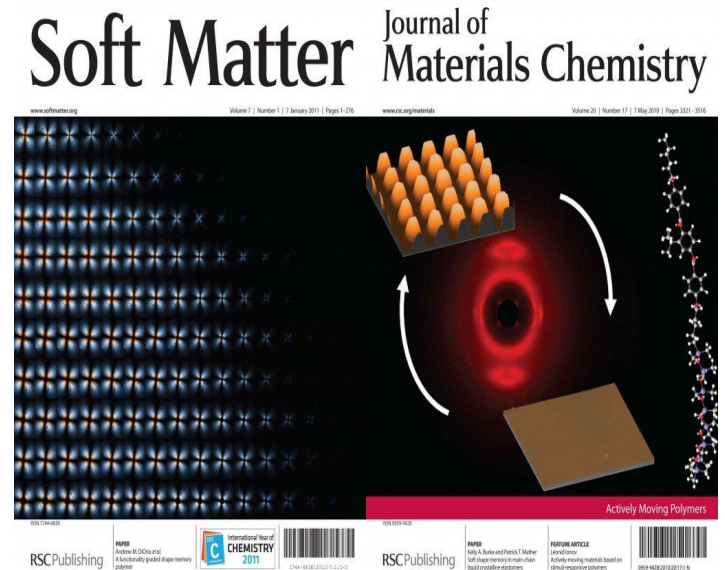


Polymer nano composite -Applications

Nano composites are used in a diverse area



Auto cooling waist support



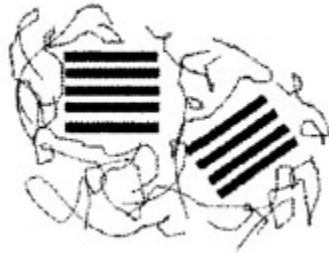
As an actively moving polymer

Objectives of the study

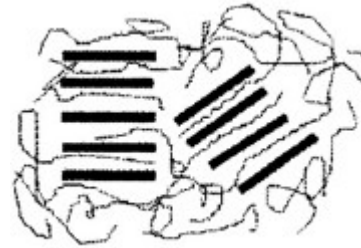
Nano structures for polymer nano composites

Main objective :

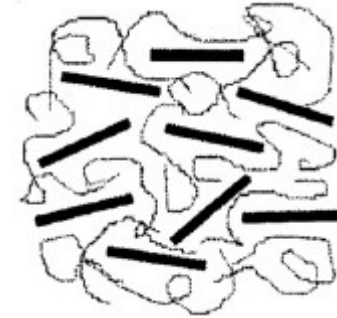
- To correlate the property enhancement of the nano composite (modulus) with it's micro structure



Phase separated
(micro composite)



Intercalated
(nano composite)



Exfoliated
(nano composite)

Method :

- Use of different nano structures to prepare the polymer nano composite : nano structures with
 - Different aspect ratios (Graphite oxide, nano clay)
 - Different state of layered nano structures as intercalated or exfoliated
- Effective characterization of morphology and chemical interaction of the nano composite to build the structure-property relationship (AFM, XRD, FT-IR, DMA)

Experimental method

Polymer nano composite preparation

- Polymer : polyurethane (PU) elastomer

Polymerization of -Polytetramethylene ether glycol (4000 molecular weight) : MDI : Ethylene glycol = Diol : MDI :EG = 1.3:1 :0.3 . Polymerized in N,N'- Dimethyl acetamide (DMAC) under N₂ environment

- Nano filler preparation

- MMT – Montmorillonite as received (Sigma Aldrich) dispersed in DMAC and ultra sonicated (35kHz) for 2 hours.
- OMMT – organically modifies Montmorillonite as received (Sigma Aldrich) dispersed in DMAC and ultra sonicated (35kHz) for 2 hours.
- GO – Graphite oxide nano platelets were prepared from flake graphite using improved Hummer's method.

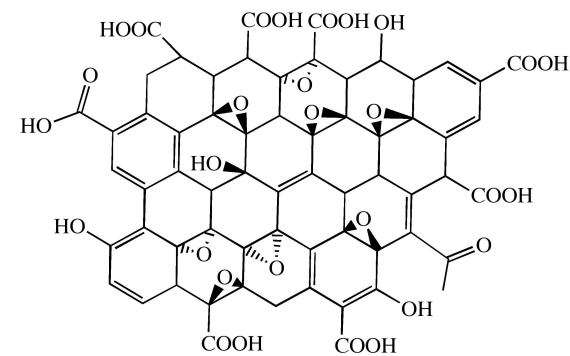
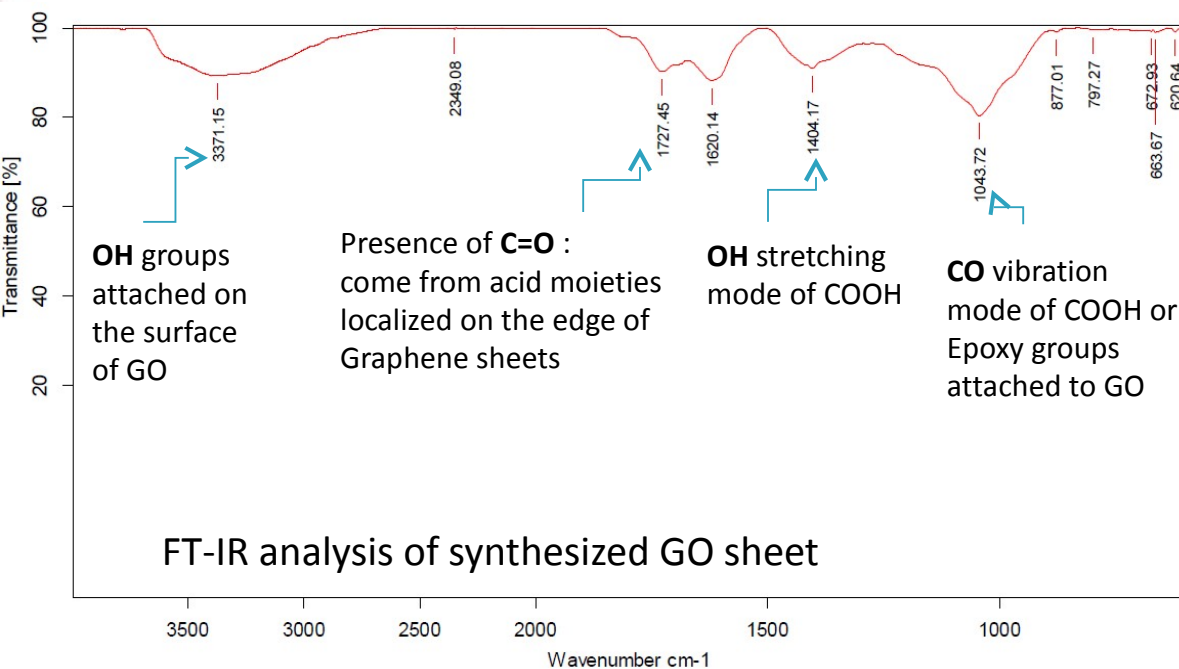
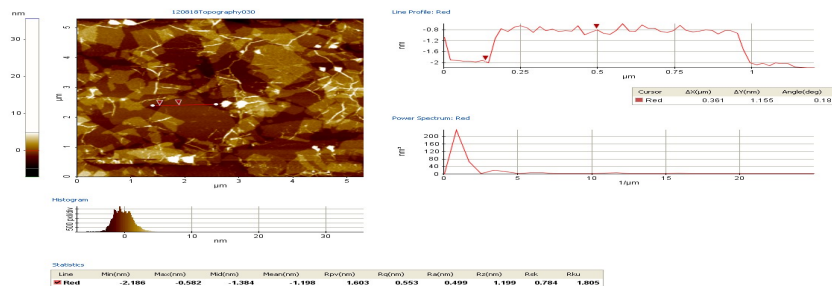
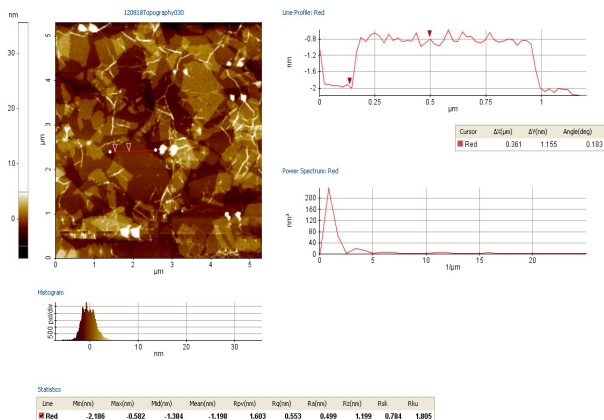
Polymer nano composite preparation

- Nano composite preparation:
 - PU/MMT - PU:MMT= MMT 5% on weight of PU. MMT dispersed in PU and ultrasonicate for 4 hours
 - PU/ OMMT – PU:OMMT = OMMT 5% on weight of PU. OMMT dispersed in PU and ultrasonicate for 4 hours
 - PU/GO – PU: GO = GO 2.8% on weight of PU. Prepared GO nano platelet s were dispersed in DMAC (1.5mg/100ml) and ultra sonicated for 1hour. To prepare GO/ PU composite, calculated amount of GO dispersion was mixed with PU and ultrasonicate for 1hour.

Results and discussion

GO from flake graphite

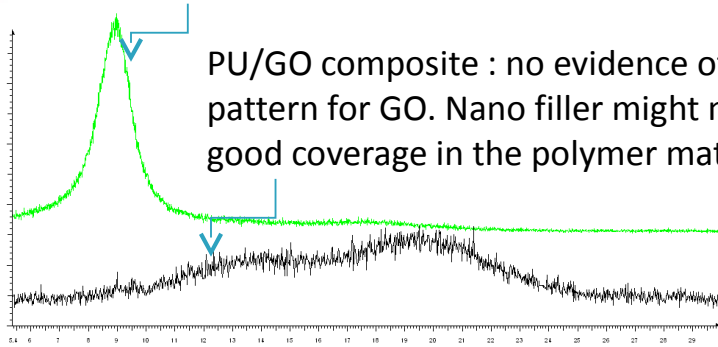
GO prepared using improved Hummer's method provide single (fully exfoliated) Graphite Oxide sheet with thickness of 1 nm



Chemical structure proposed for GO

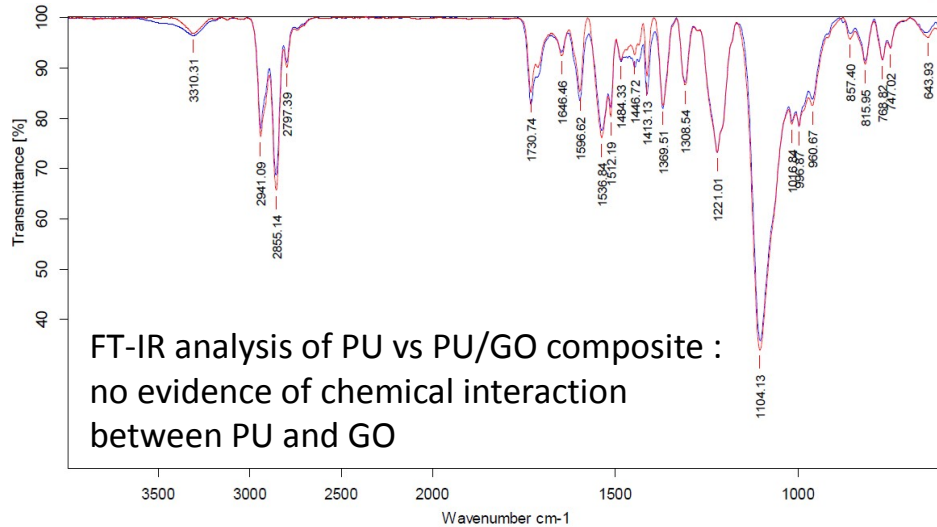
PU/GO composite

Synthesized GO : Basel peak at 2θ of 11.52° .
Layer spacing (d spacing) of 8.56 \AA



PU/GO composite : no evidence of crystallized pattern for GO. Nano filler might not have given good coverage in the polymer matrix

XRD analysis of GO and PU/GO



FT-IR analysis of PU vs PU/GO composite :
no evidence of chemical interaction
between PU and GO

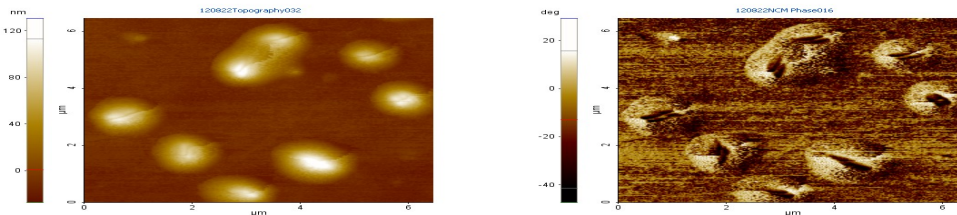
AFM analysis :

Phase contrast image indicate **existence of two phases in the polymer composite**. Evidence of the nano filler (**GO**) presents as **clumps** on the polymer matrix. During sheet casting the nano fillers tends to come to the surface of the sheet indicating **weak interaction of filler with polymer matrix**

AFM analysis of PU/GO composite using Non Contact mode :

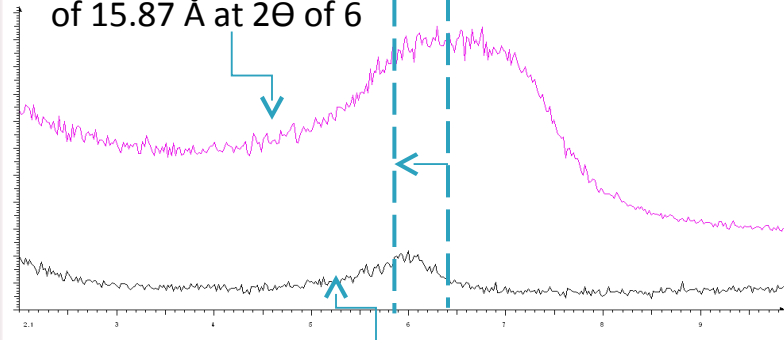
Left- Topographic image

Right – Phase angle measurement



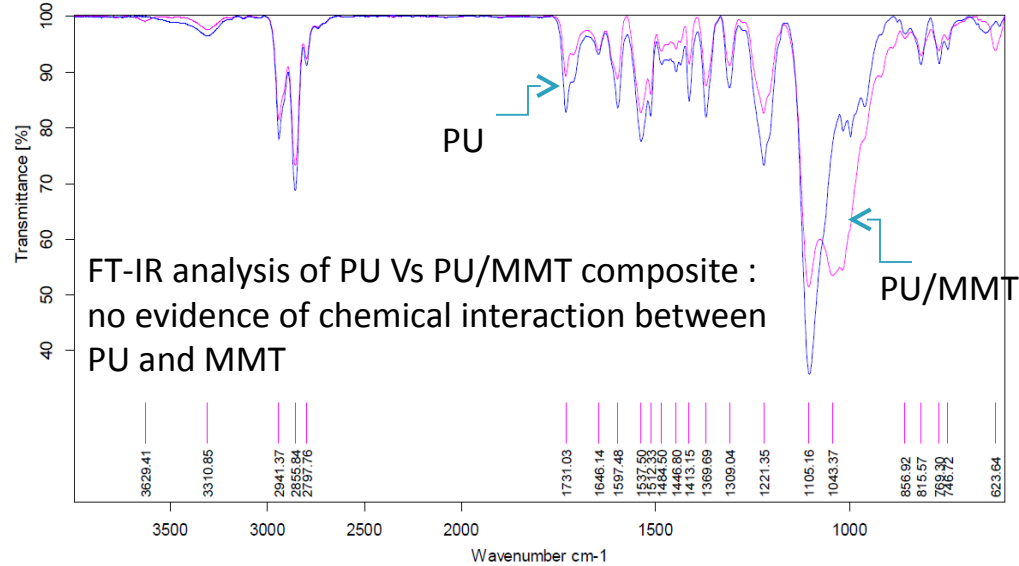
PU/MMT composite

Bare MMT indicate a layer spacing of 15.87 Å at 2θ of 6



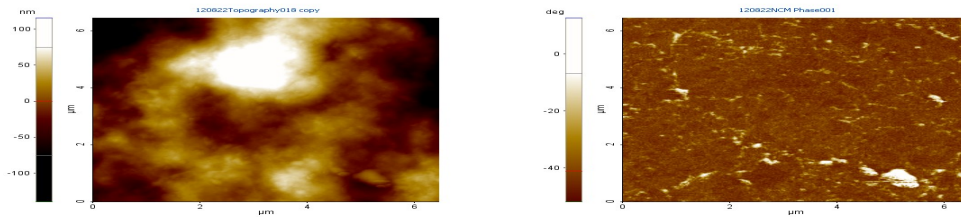
PU/ MMT composite indicate a layer spacing of MMT of 16.65 Å at 2θ of 6°. Evidence of intercalation of MMT structure in the polymer matrix

XRD analysis of MMT and PU/MMT



FT-IR analysis of PU Vs PU/MMT composite : no evidence of chemical interaction between PU and MMT

AFM analysis :



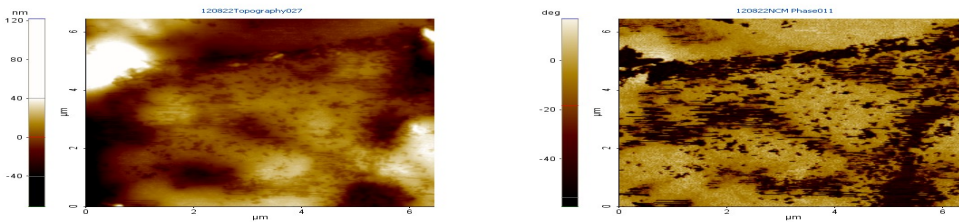
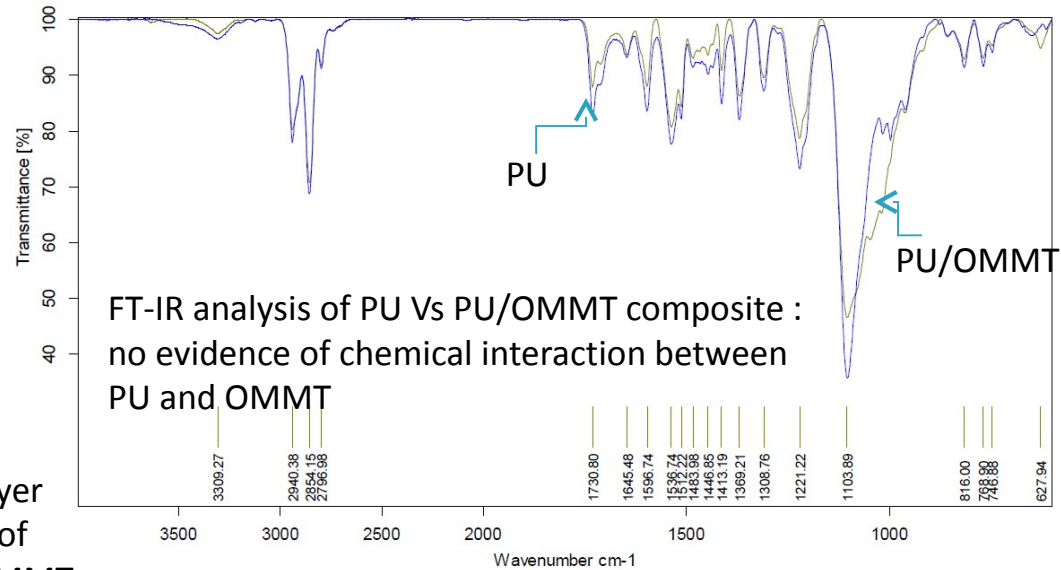
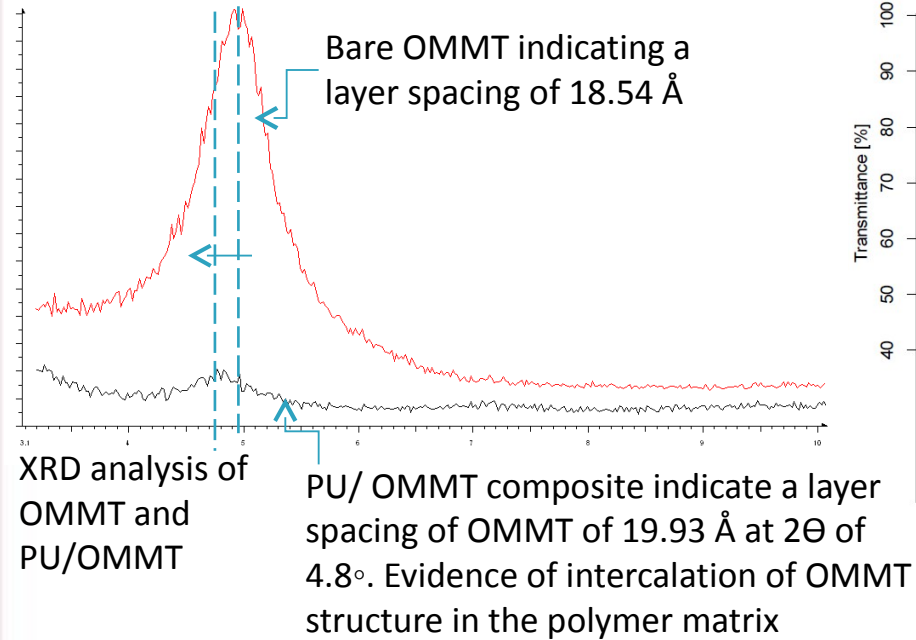
Phase contrast image indicate **existence of two phases in the polymer composite** as MMT and polymer . **Relatively good dispersion** of the nano filler on the polymer matrix.

AFM analysis using Non Contact mode :

Left- Topographic image

Right – Phase angle measurement

PU/OMMT composite



AFM analysis :

Phase contrast image indicate **existence of OMMT in polymer as two phases**. Evidence of the nano **OMMT presents as a homogenous filler** on the polymer matrix.

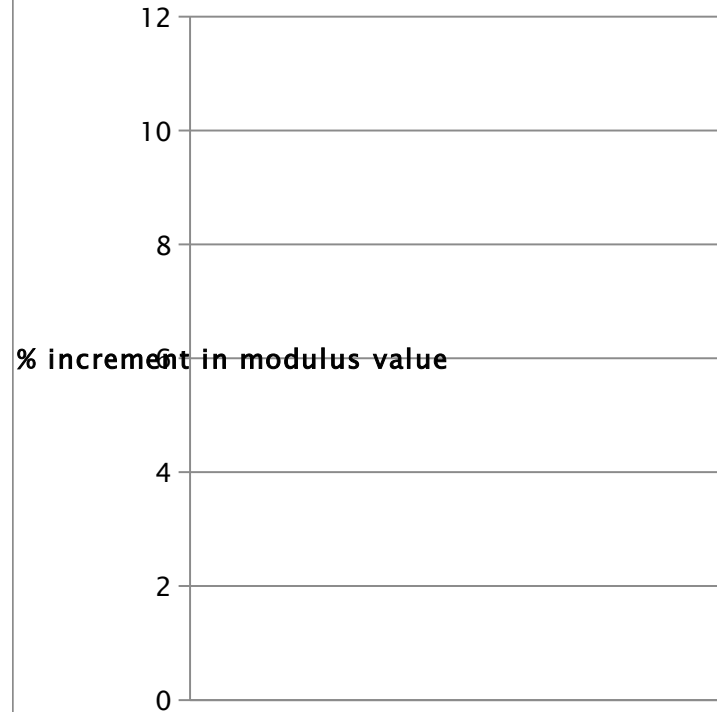
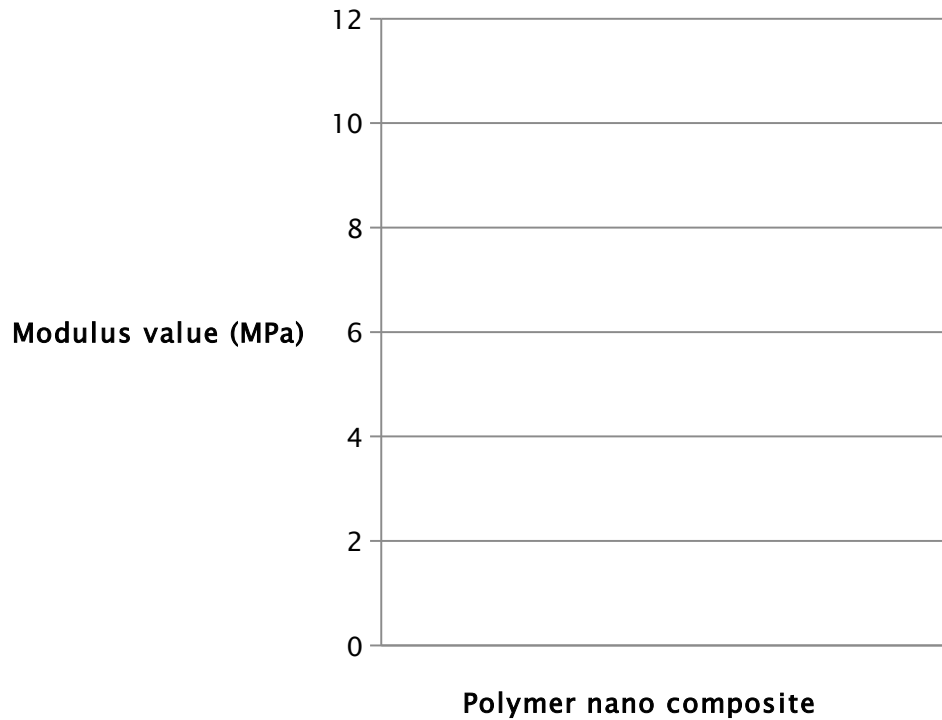
AFM analysis using Non Contact mode :

Left- Topographic image

Right – Phase angle measurement

Polymer nano composite property analysis

- Modulus values of the prepared composites were been analyzed using DMA (Dynamic Mechanical Analyzer) under tension mode.

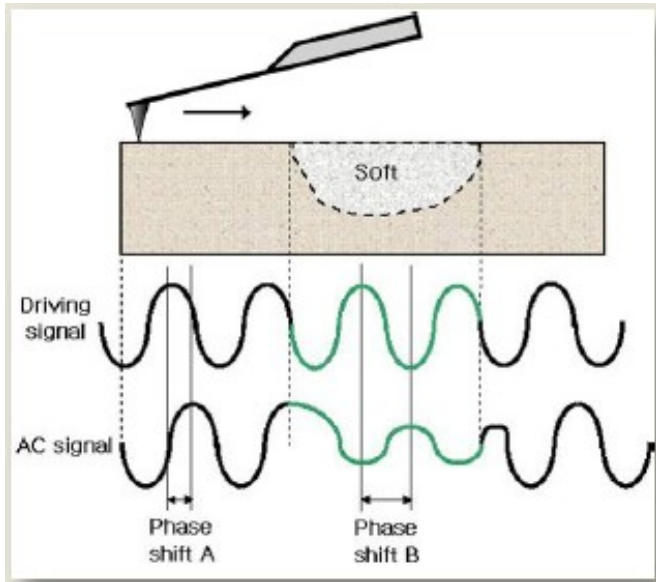


Conclusion

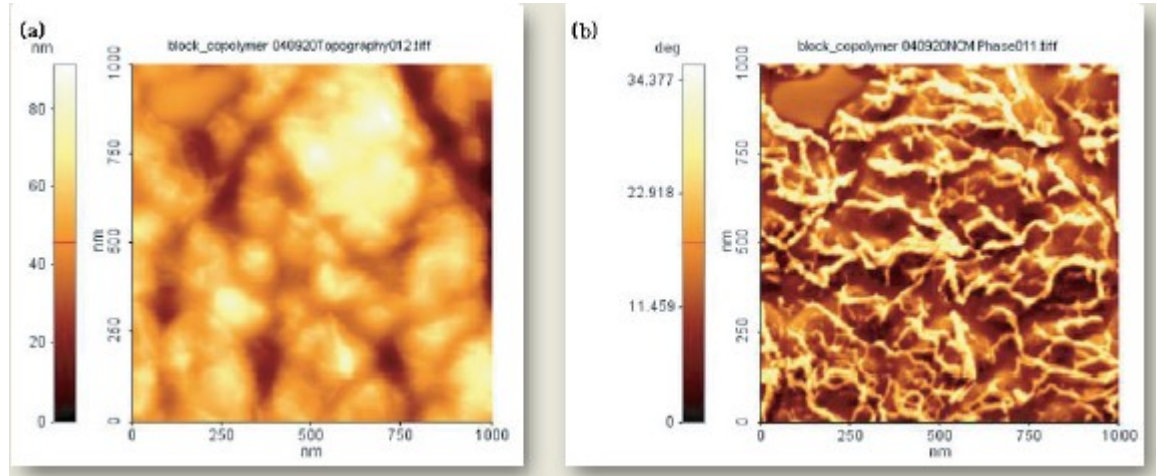
Property enhancement of nano composite with it's micro structure

- With the functional groups present in the GO, it is makes sable dispersions with polar solvents (water). Hence can not make good adhesion with non polar polymer matrix.
- The exfoliated state of the GO sheet had not been achieved inside the polymer matrix. Therefore a micro composite was been achieved.
- Reduction or surface functionalization of GO inside the polymer matrix will be able to make a (exfoliated) PU/GO nano composite.
- MMT and OMMT was able to produce intercalated polymer nano composite. Since OMMT was able to achieve a good surface coverage inside the polymer matrix it showed a relatively higher modulus value.

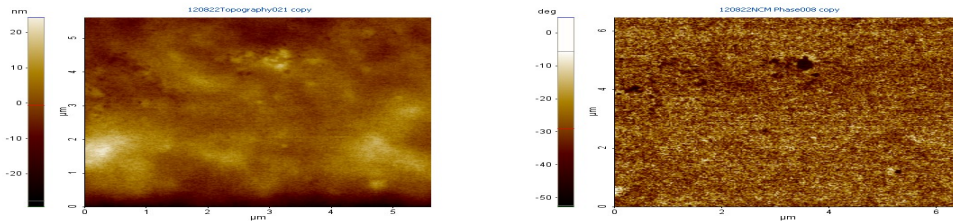
Thank you



Phase lag of the cantilever oscillation depending on the mechanical properties of the sample



Non contact AFM image of a block copolymer (a) topographic image (b) phase image



AFM analysis of PU sheet using Non Contact mode :
 Left- Topographic image
 Right – Phase angle measurement