Years with Chemistry and Nanotechnology from Research to Life Pathway

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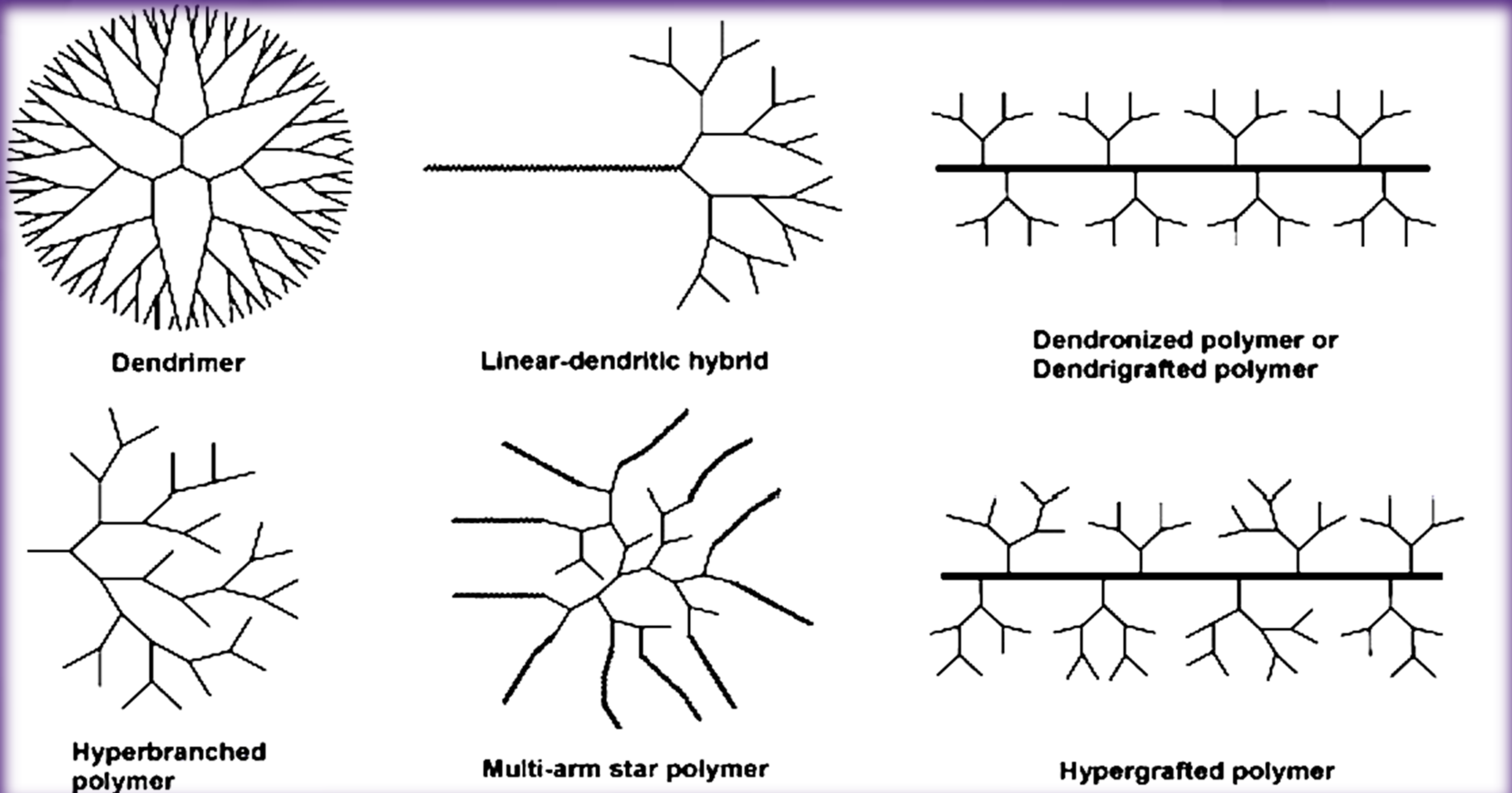
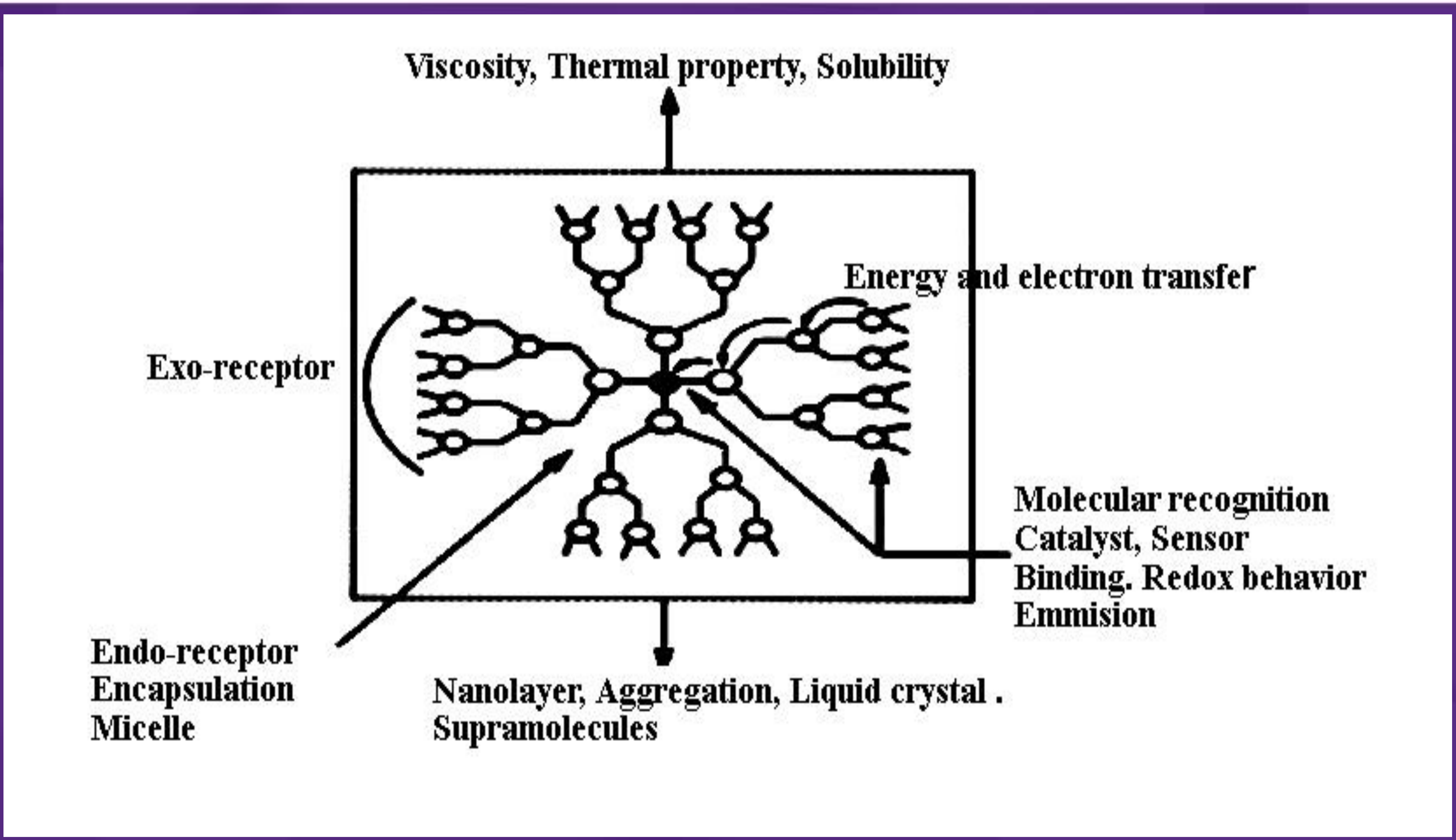
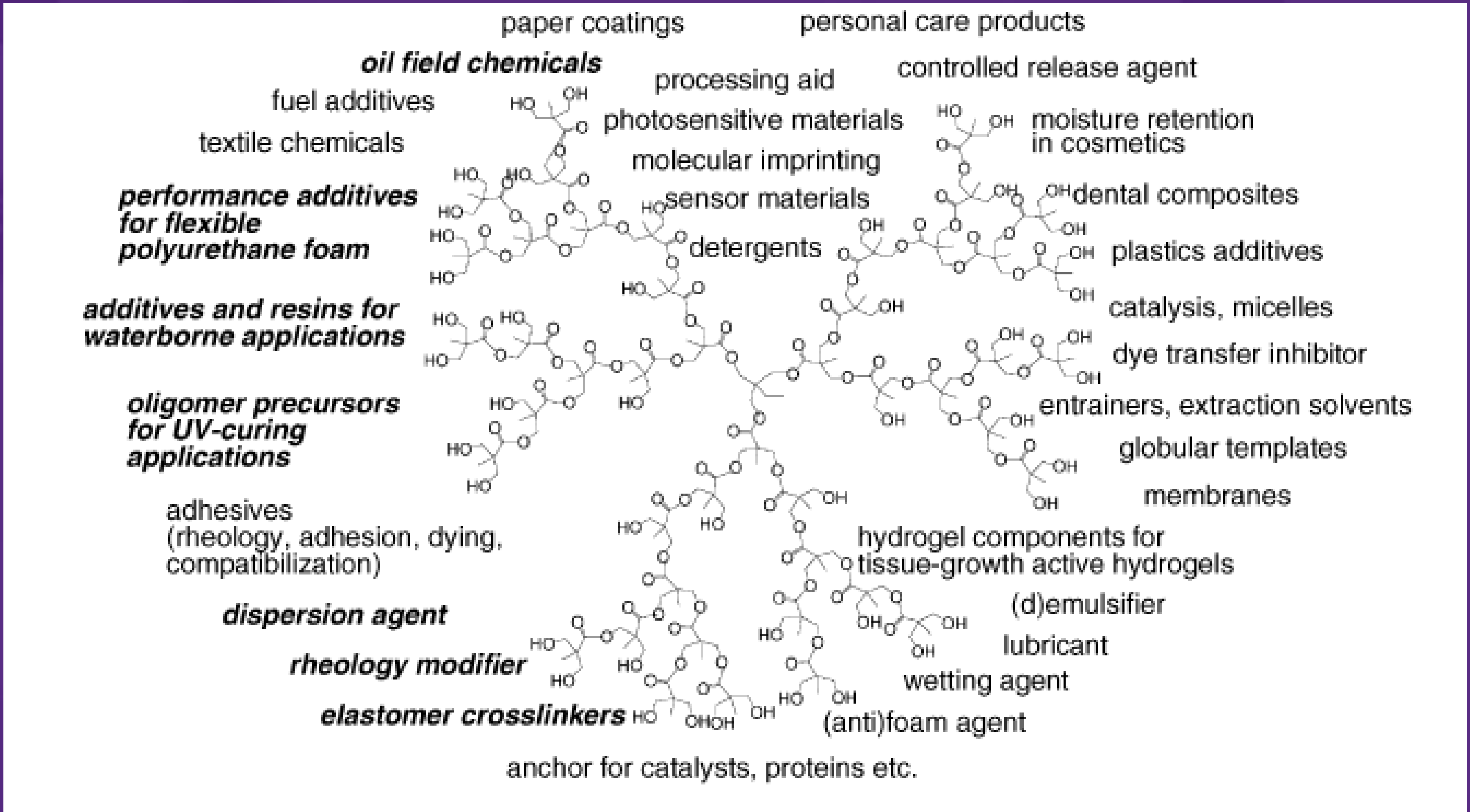
Dendritic polymers



Applications of Dendrimers



Applications of hyperbranched polymers



Projects and Topics of Research

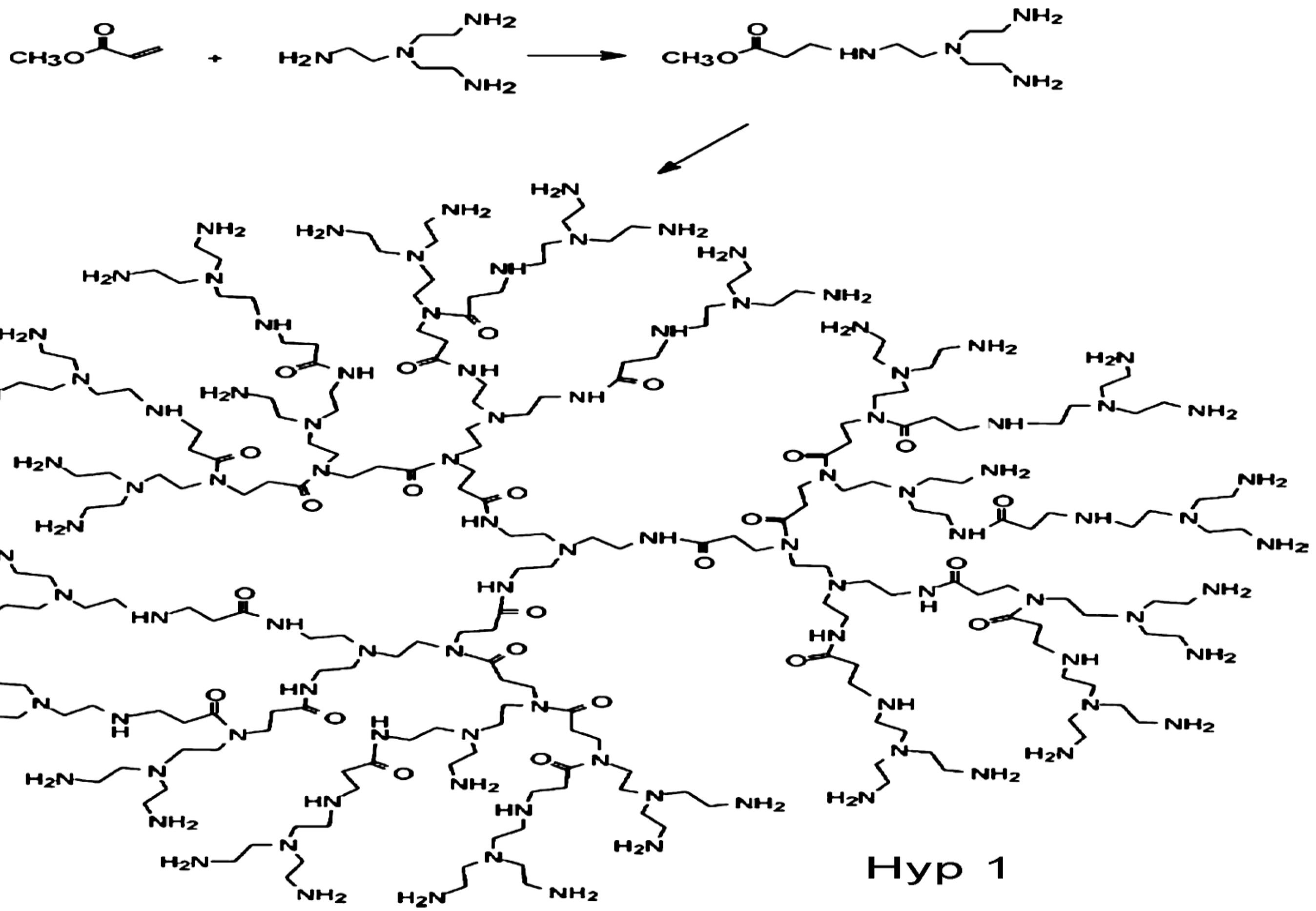
- Hyperbranched polymers and their applications in the biomedical industries.
- Nanostructured polymers-clay nano-composites for various industrial applications.(Egypt-France)
- Manufacturing of cement containing functional and nano-structured polymers on the way for better construction materials and high performance buildings.

Projects and Topics of Research

- Hyperbranched polymers as pretanning agent
- Poly(ester-amine) hyperbranched polymer as toughening and co-curing agent for epoxy/ clay nanocomposites.
- Glycopolymers, on the way of new bionano-polymers for biomedical applications.(Egypt-US)

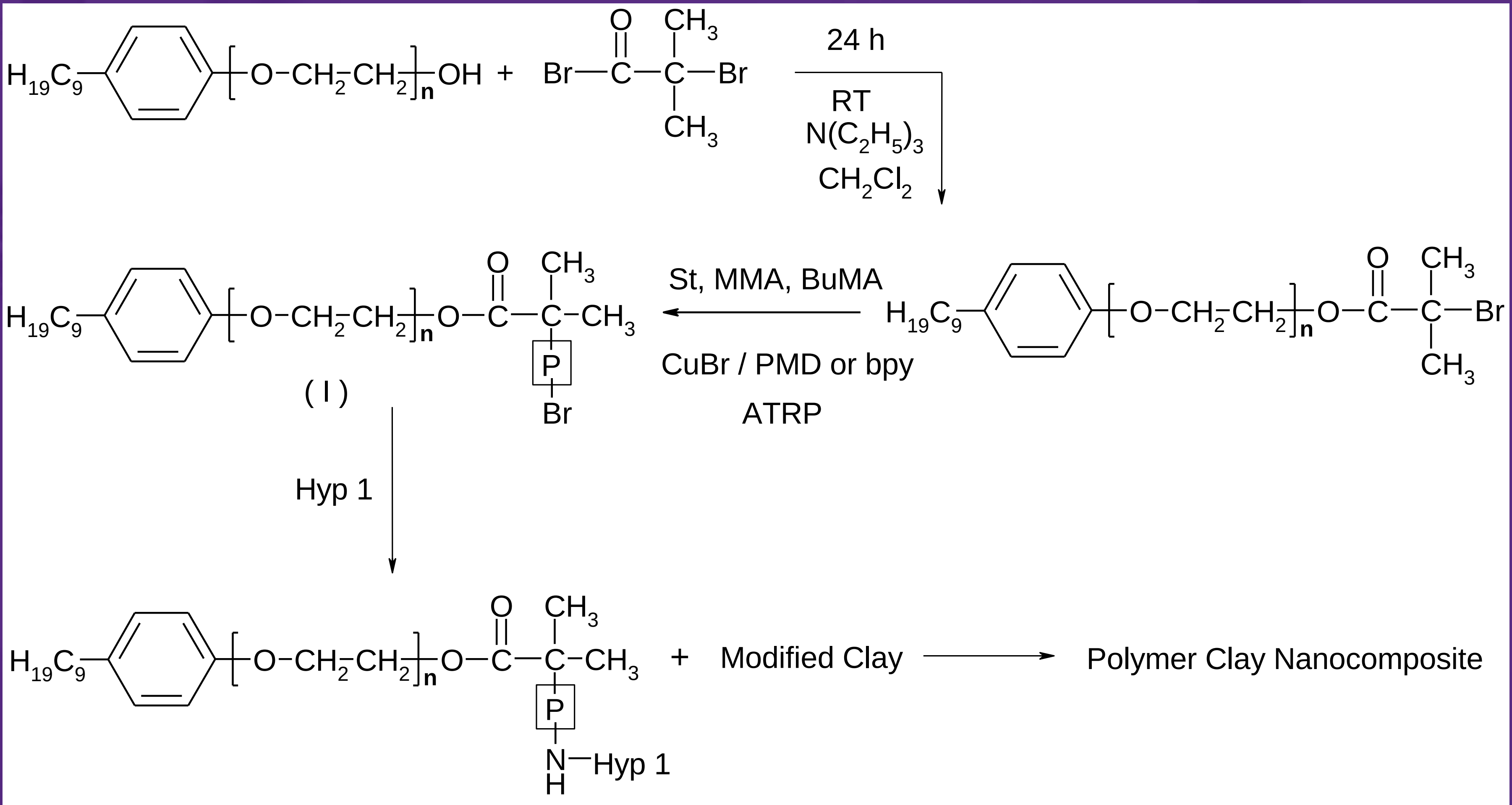
II. Hyperbranched polymer/Clay nanocomposites

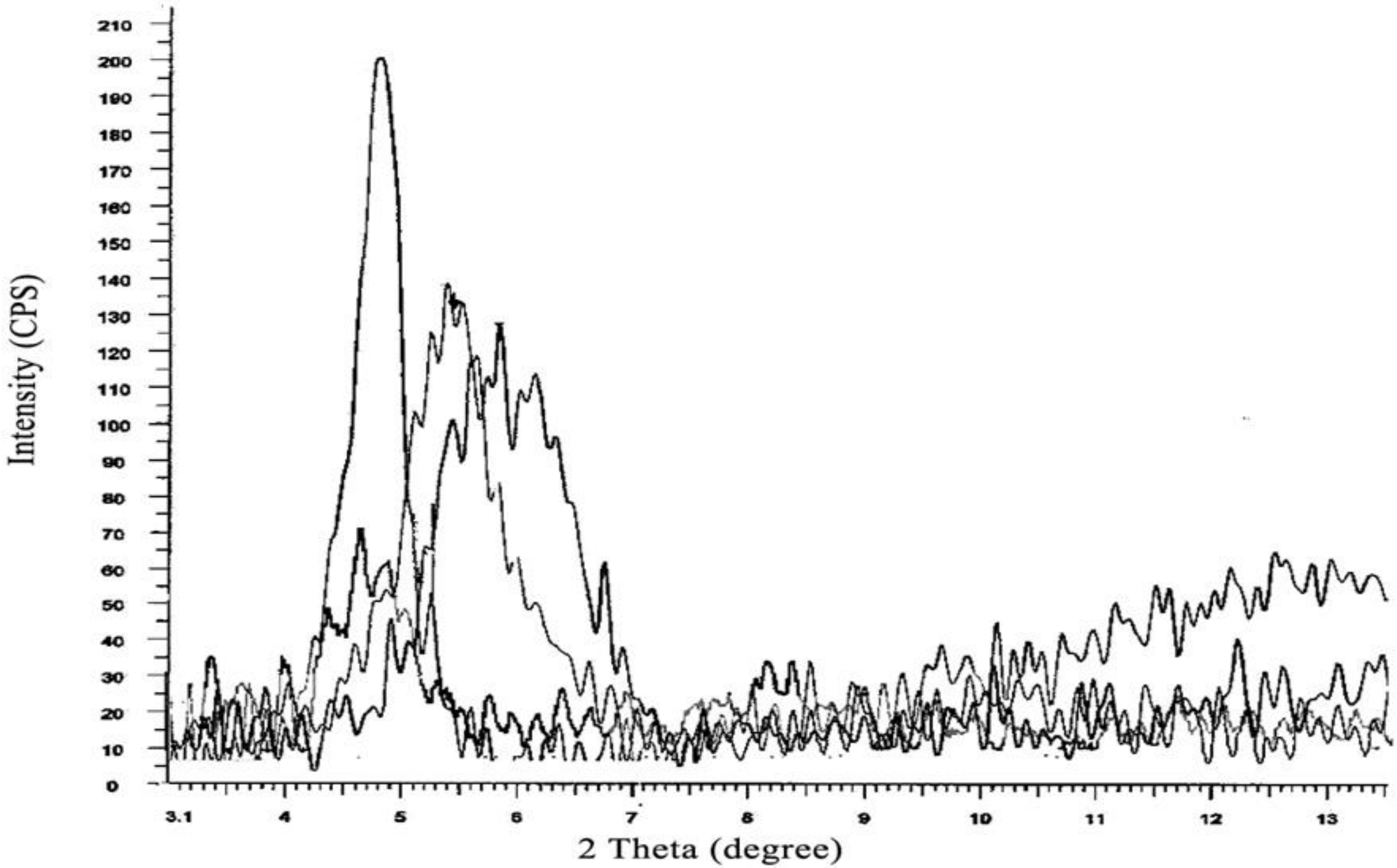
Polyamidoamine hyperbranched polymer



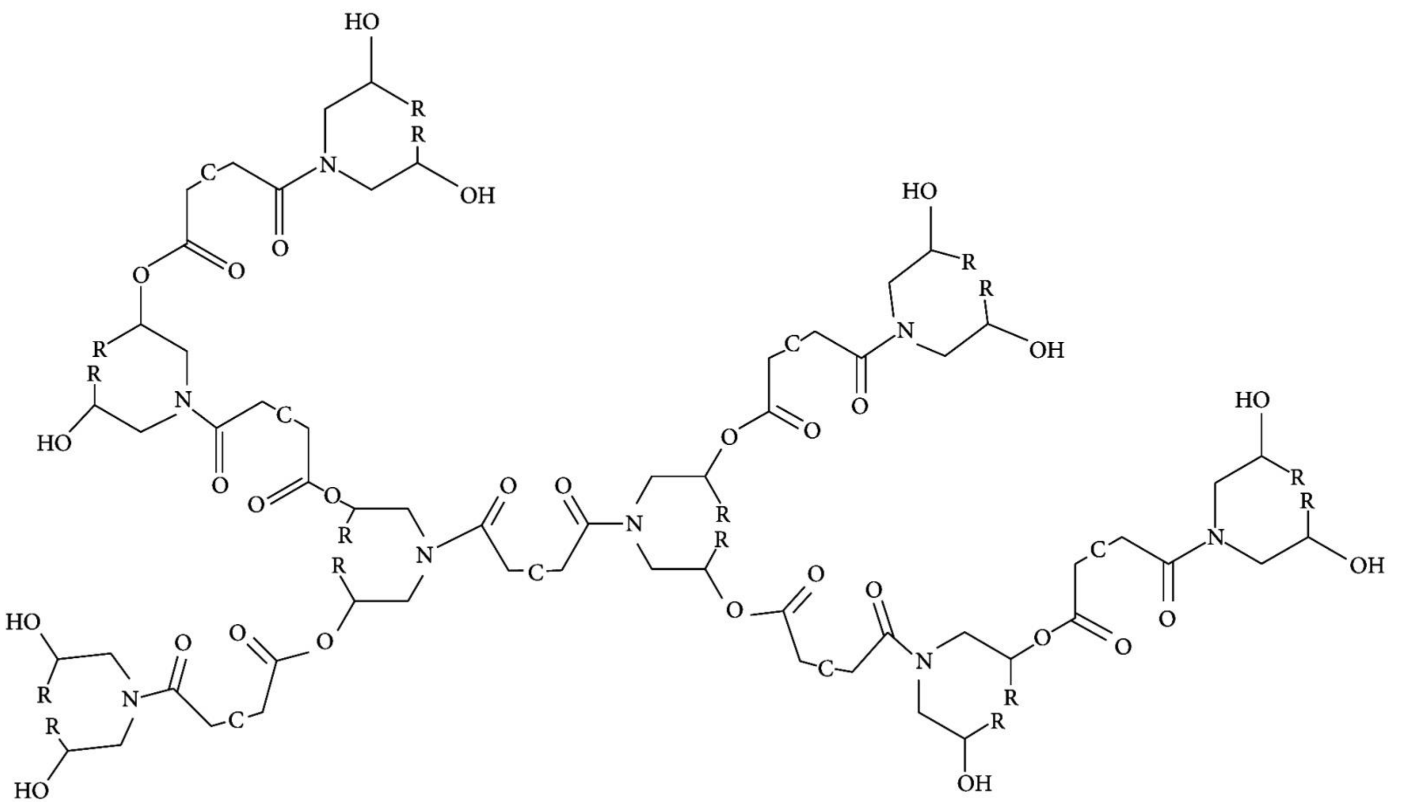
Hyp 1

II. Hyperbranched polymer/Clay nanocomposites.




Intensity (CPS)
210
200
190
180
170
160
150
140
130
120
110
100
90
80
70
60
50
40
30
20
10
0
3.1
4
5
6
7
8
9
10
11
12
13
2 Theta (degree)

Polyesteramide hyperbranched polymer

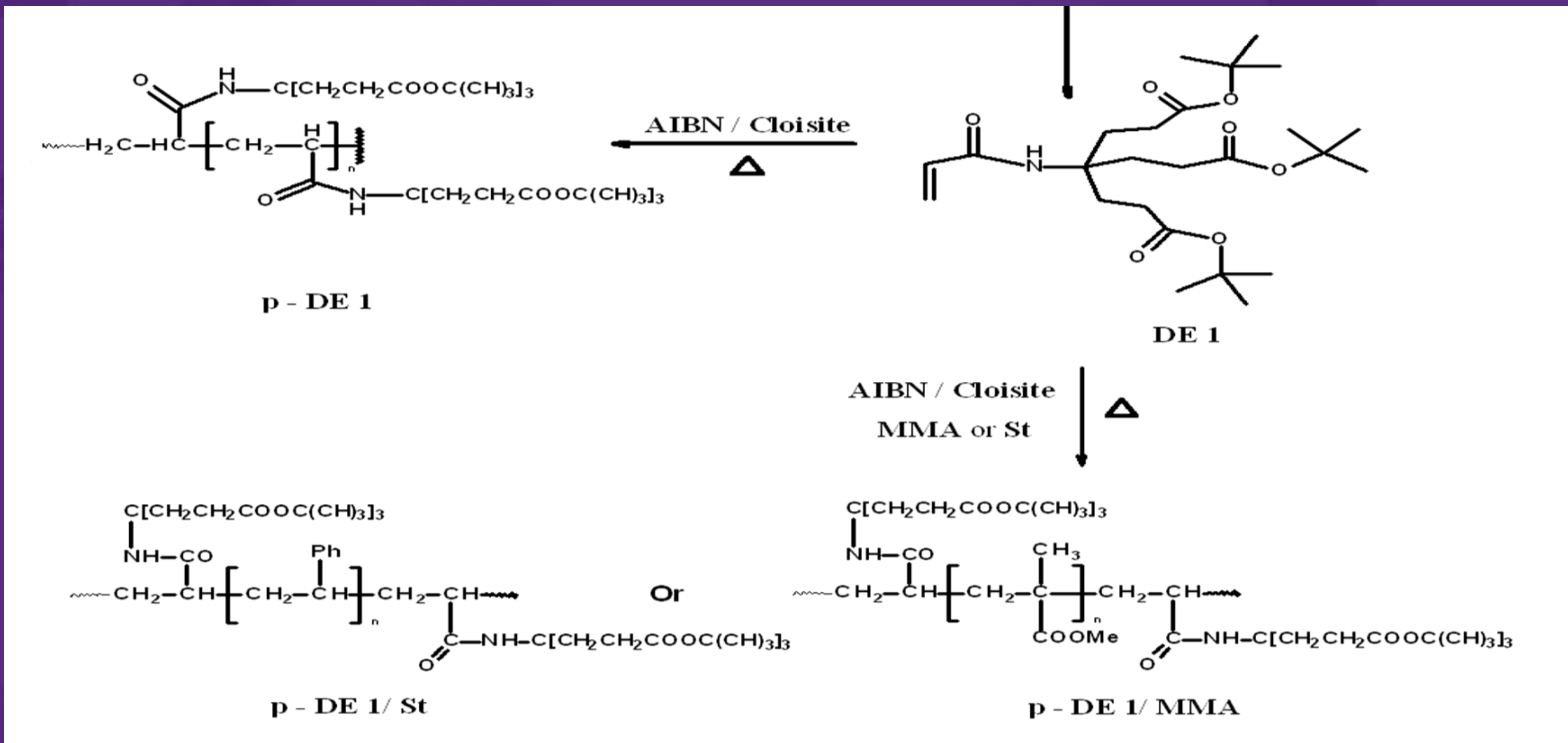


Where HPEA$_{1,2}$: R = H, CH_3, C = maleic anhydride,

HPEA$_{3,4}$: R = H, CH_3, C = succinic anhydride,

HPEA$_{5,6}$: R = H, CH_3, C = phthalic anhydride

Dendrimers

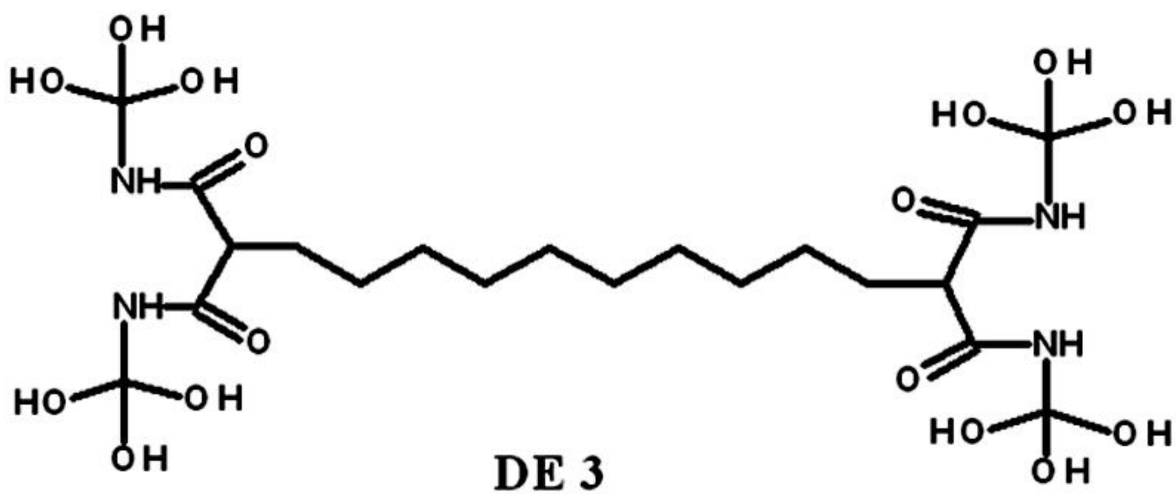


AIBN / Cloisite
p - DE 1
DE 1
AIBN / Cloisite
MMA or St
Or
p - DE 1/ St
p - DE 1/ MMA

DE2 - DE3

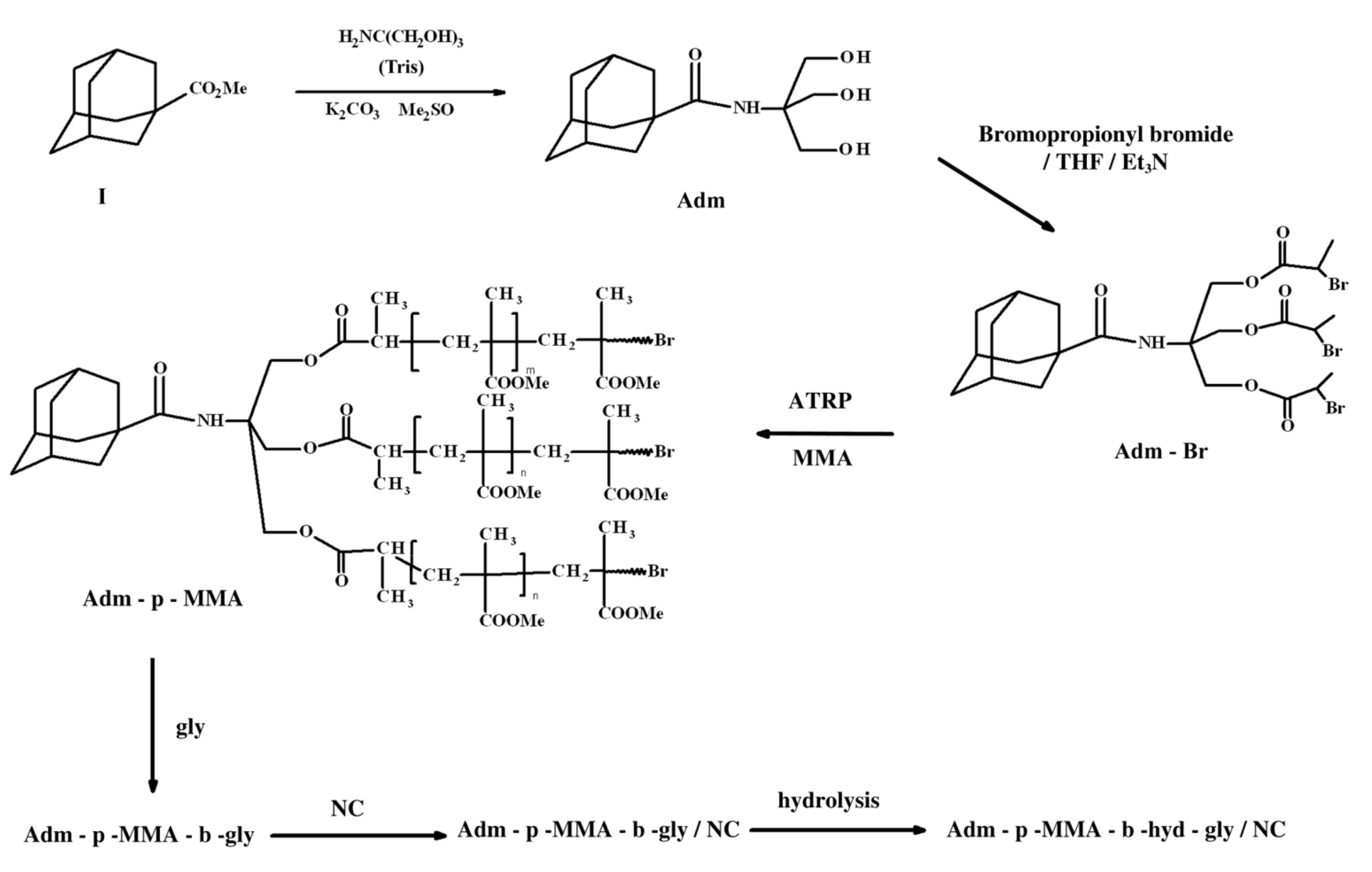
$C[CH_2OCH_2CH_2CONHC(CH_2CH_2CONHC[CH_2CH_2CO_2H]_3)_3]_4$

DE 2



DE 3

Preparation of Dendritic Admantane and its Nanocomposites



III. Manufacturing of cement containing nano-structured polymers

- The main objectives of our project are:
- Preparation and characterization of some hyperbranched polymers and insertion of such polymers in the cement pastes.
- Then, the properties of the polymer/cement pastes will be preciously measured such as water of consistency, setting time, compressive strength, and combined water content.

III. Manufacturing of cement containing nano-structured polymers

- The negatively charged cement particles are formed by the adsorption of the polymer molecules onto the cement surface. Hence, electrostatic repulsion is generated between the cement particles reducing the inter particle attraction and preventing flocculation or agglomeration where well-dispersed system is obtained.
- That fact leads to better properties of the formed cement pastes such as better hydration by using less water to penetrate between the particles.

The Role of Hyperbranched Polymers

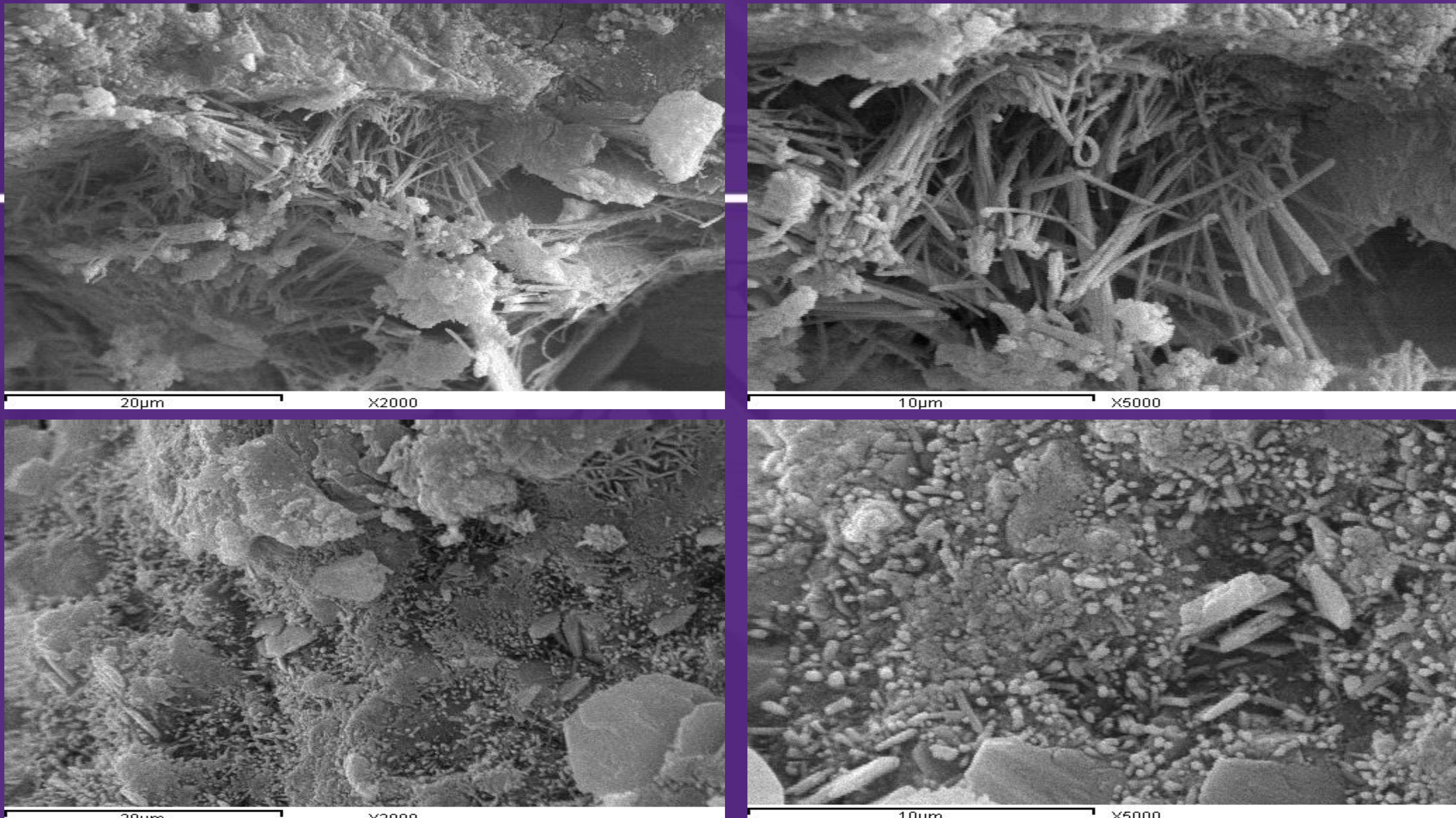
- The amount of hydration products increases by the deposited polymers in the pore spaces of the hardened cement pastes, in addition to the formed polymer film which fills up the pores of the cement pastes. Consequently, the density increases and the porosity decreases. All these factors positively contribute to the compressive strength of the resulting cement. Therefore, hyperbranched polymers can be used as a water-reducing agent, plasticizer or super-plasticizer.

III. Manufacturing of cement containing nano-structured polymers

- Enhanced properties of the produced cement are expected.
- Therefore, obvious industrial economic impact is expected by increasing the quality of the resulting cement pastes by slight addition of such functional hyperbranched polymers in easy and economic way.

- The prepared polymer (HBPA) reduced the w/c ratio by more than 12-20% comparing with the blank, and therefore it can be used as a water-reducing agent, plasticizer or super-plasticizer.
- HBPA activated the cement phases and improved the rate of hydration and combined water contents at all curing ages of hydration.
- The mechanical strength was also improved and enhanced, particularly at later ages of hydration.

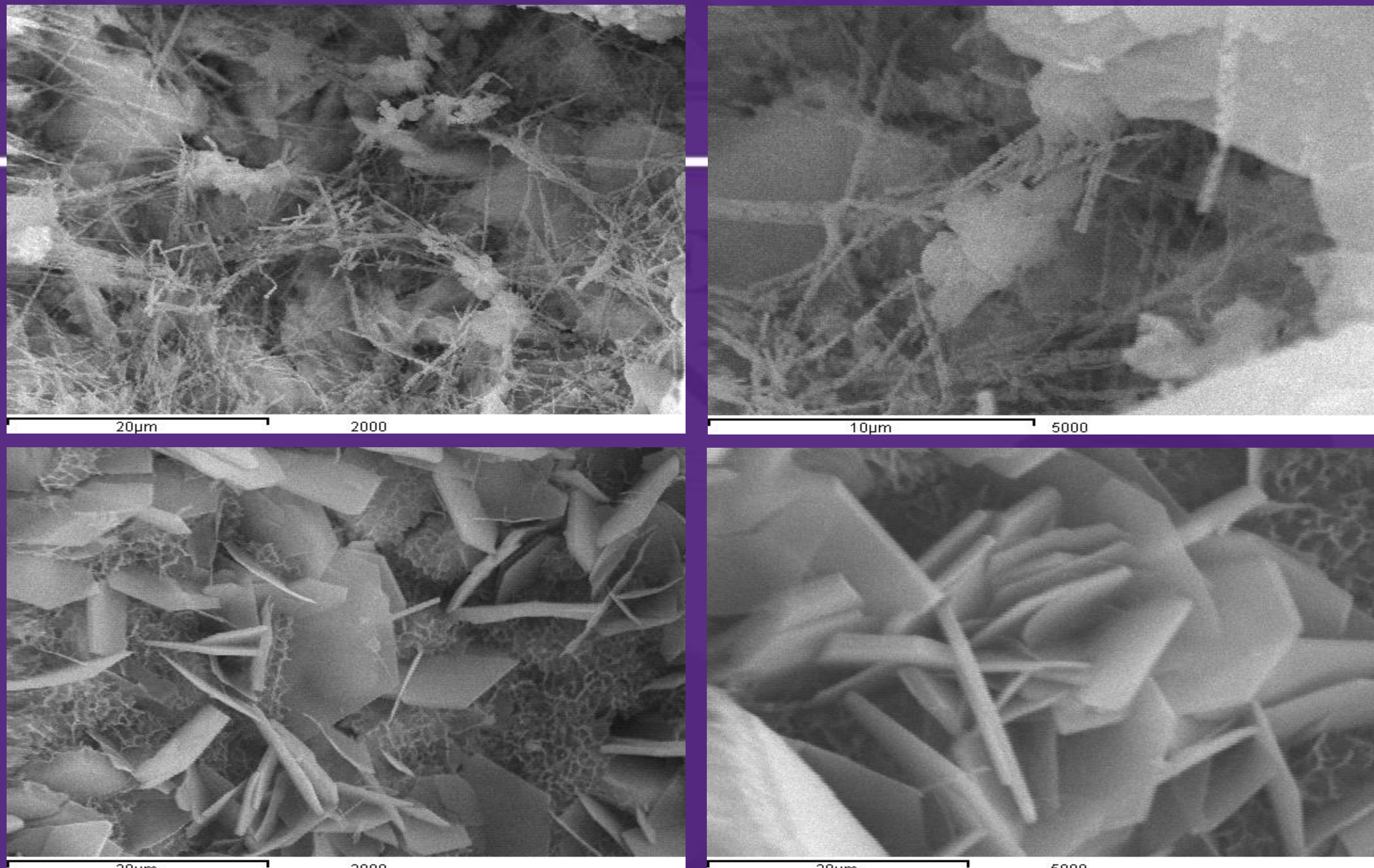
M0 (a) M0 (c)



M5 (b) M5 (d)

The SEM micrographs of OPC pastes (a and c) and those premixed with polymer (b and d) hydrated up to 90 days

MO (e) MO (g)



MO (f) MO (h)

The SEM micrographs of LPC pastes (e and g) and those premixed with polymer (f and h) hydrated up to 90 days

Glycopolymers

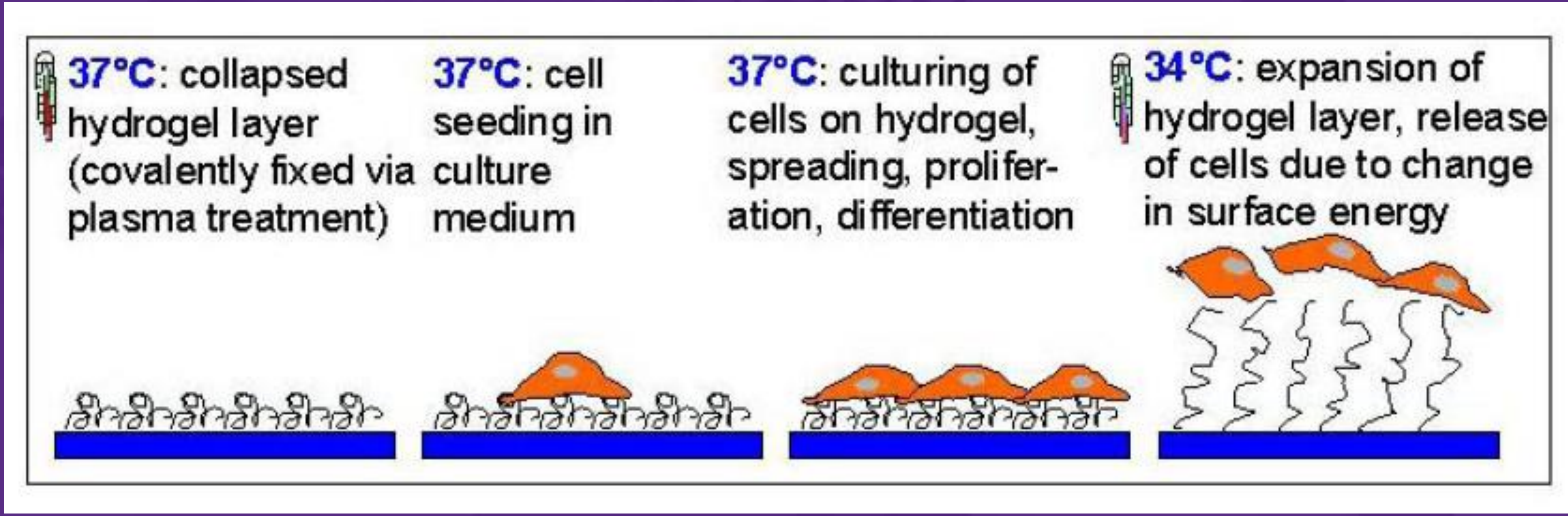
On The Way to New Biopolymers for Medical Applications

- Glycopolymers are synthetic polymers containing sugar moieties as pendant groups or terminal groups, apart from whether they show biological functions or not.
- They may include chemically modified natural polymers, such as cellulose and chitin grafted to synthetic polymers.
- Protein–saccharide interactions participate in cellular recognition, adhesion, cancer cell metastasis, and infection of pathogens.

Hydrogels

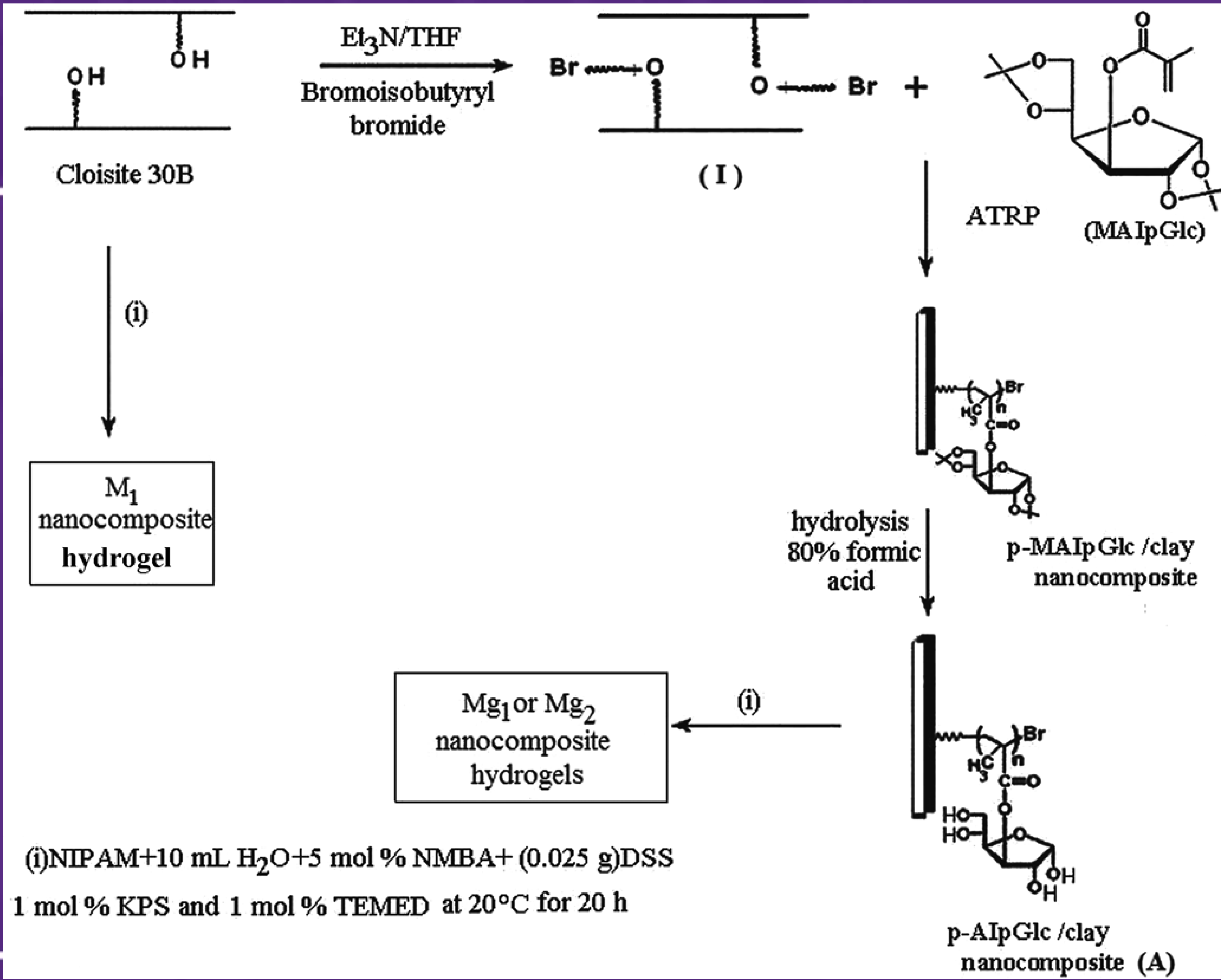
- Much interest has been directed at sugar-based hydrogels because of their biocompatibility and hydrophilic nature.
- Sugar-based hydrogels are expected to be new substrates for cell growth.
- Replacing agar, normally used in culture plates, with hydrogels containing specific sugars improve the adhesion or growth characteristics of microbial and mammalian cells.

Hydrogels


37°C: collapsed hydrogel layer (covalently fixed via plasma treatment)
37°C: cell seeding in culture medium
37°C: culturing of cells on hydrogel, spreading, prolifer-ation, differentiation
34°C: expansion of hydrogel layer, release of cells due to change in surface energy

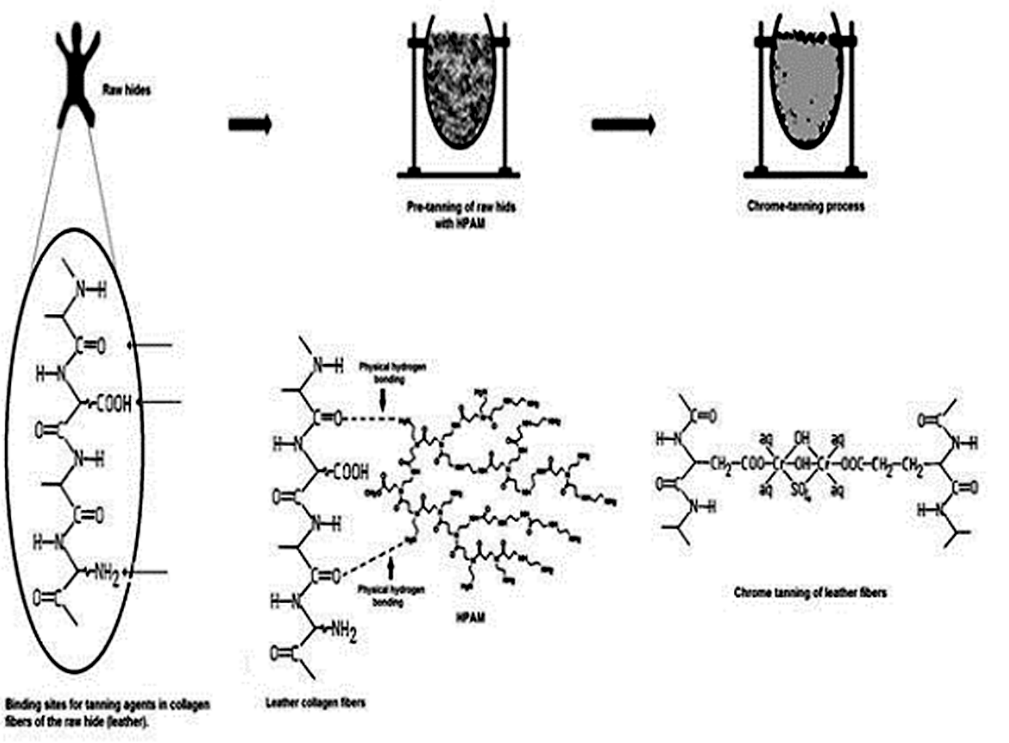
Preparation of N-Isopropylacrylamide/Clay Nanocomposite Hydrogels containing Glycopolymer Grafts

- The presence of glycopolymer units provided their nanocomposite hydrogels with higher thermal stability and higher swelling ratios than those containing clay only.



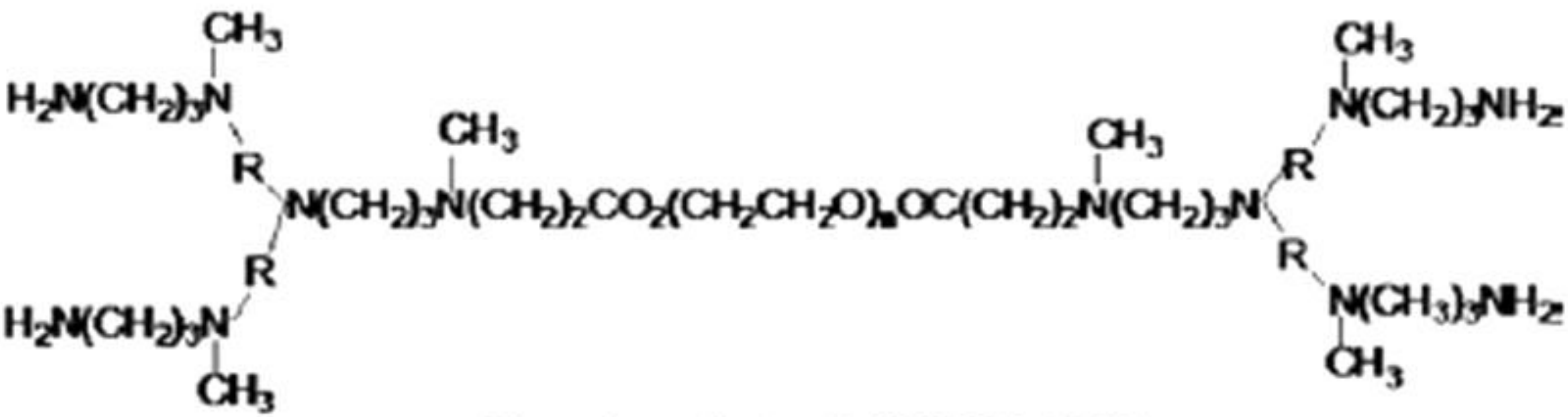
Et3N/THF
Bromoisobutyryl bromide
Cloisite 30B
(I)
ATRP
(MAIpGlc)
(i)
M1 nanocomposite hydrogel
hydrolysis 80% formic acid
p-MAIpGlc /clay nanocomposite
(i)
Mg1 or Mg2 nanocomposite hydrogels
(i)NIPAM+10 mL H2O+5 mol % NMBA+ (0.025 g)DSS
1 mol % KPS and 1 mol % TEMED at 20°C for 20 h
p-AIpGlc /clay nanocomposite (A)

Hyperbranched polymers as pretanning agent



Employing of poly amidoamine hyperbranched polymer (HPAM) as pre-tanning agent for leather

Poly(ester-amine) hyperbranched polymer as toughening and co-curing agent for epoxy/ clay nanocomposites



Hyperbranched poly(PEODA-NPA)

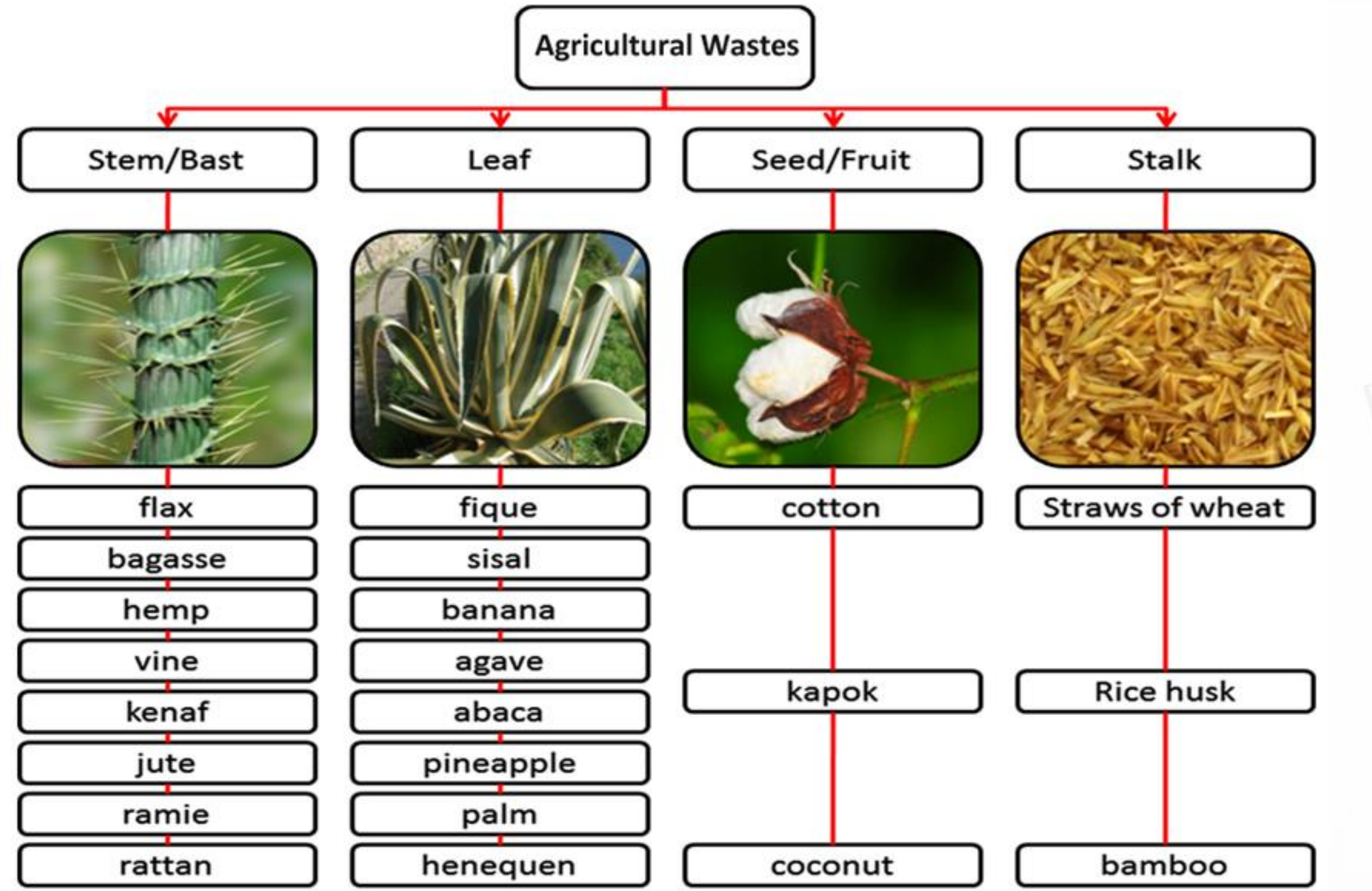
Where: $R = CH_2CH_2(CH_2CH_2O)_nOCCH_2CH_2$

Other Current Projects

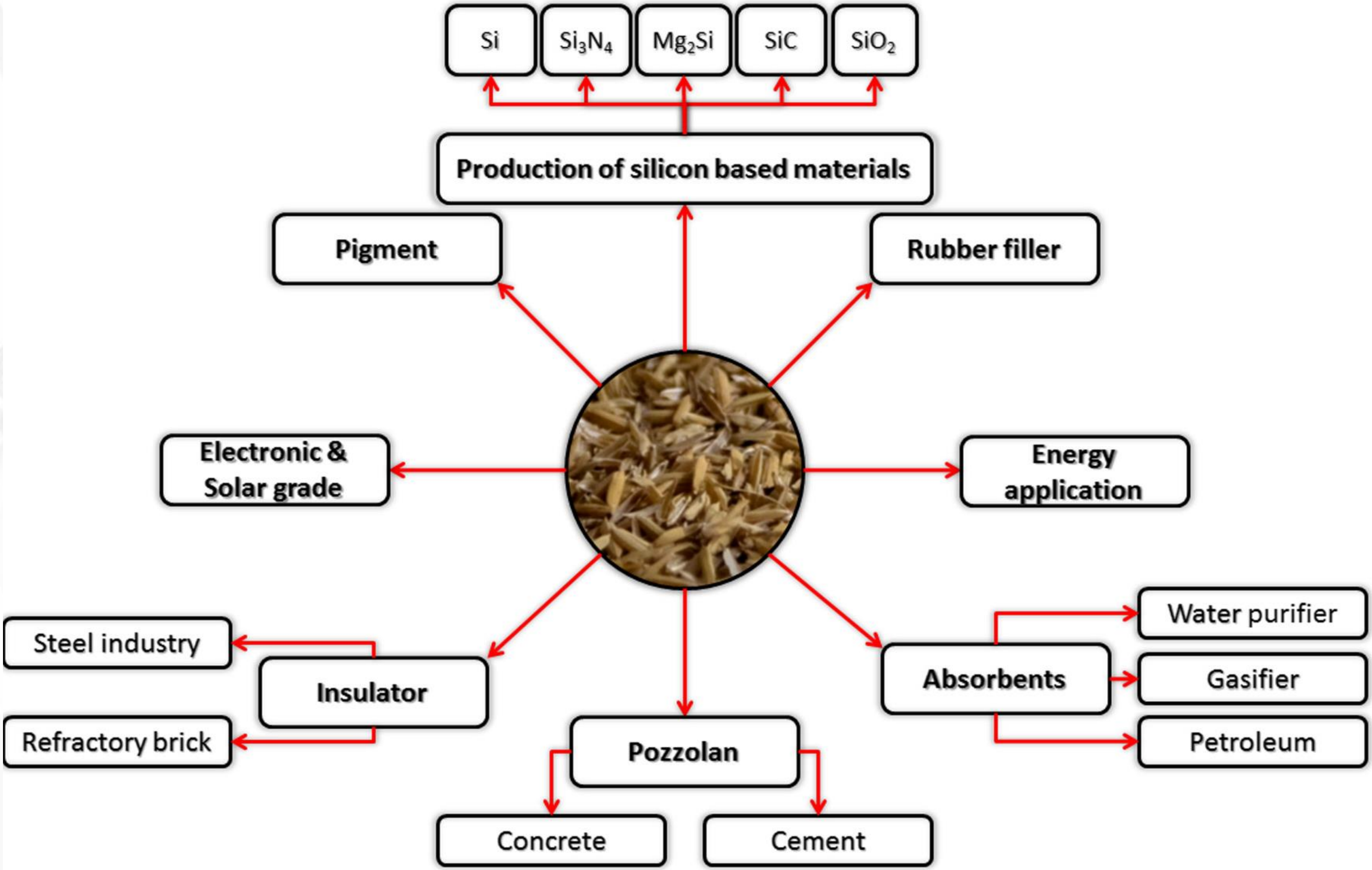
- Preparation of rice-waste reinforced urea-formaldhyde composites with improved moisture resistance.
- Hyperbranched polymers for dielectric materials and biosensors.
- Preparation and characterization of tri-component composite comprised glycopolymer grafted onto clay with chitosan/ /hydroxyapatite for biomedical applications (bone repair).
- Nanostructured polymers/agricultural wastes for biomedical applications.

Agricultural wastes

- Plenty of waste is produced due to the increased activity in the modern agricultural sector, representing a tremendous threat to the environment and to eliminate this problem scientists have taken initiative to find good uses for these wastes.


Agricultural Wastes
Stem/Bast
Leaf
Seed/Fruit
Stalk
flax
bagasse
hemp
vine
kenaf
jute
ramie
rattan
fique
sisal
banana
agave
abaca
pineapple
palm
henequen
cotton
kapok
coconut
Straws of wheat
Rice husk
bamboo

- Today, it is well-known that biomass is a rich source of energy and other daily useful products. Several new biomass-based chemicals and biomaterials are being developed and marketed as a substitute for Petroleum- based products.
- Rice husk is an agricultural by product from the rice mill, produced in abundance at low cost. Therefore, it is one of the most promising and inexpensive precursors for the production of nanomaterials.


Si
Si_3N_4
Mg_2Si
SiC
SiO_2
Production of silicon based materials
Pigment
Rubber filler
Electronic & Solar grade
Energy application
Steel industry
Insulator
Refractory brick
Pozzolan
Concrete
Cement
Absorbents
Water purifier
Gasifier
Petroleum

Limitations of using RHP in production polymer composites

- Rice husk being hydrophilic in nature is unable to coexist with hydrophobic polymeric matrices, which results in poor dispersion of fibers and cause agglomeration, which leads to poor properties of composites. Numerous researchers have studied different techniques to develop better filler diffusion and interfacial contact between filler and matrix
- Several physical ,mechanical and chemical means have been used to overcome these problems

Using nRHP as a potential nanofiller in rubber

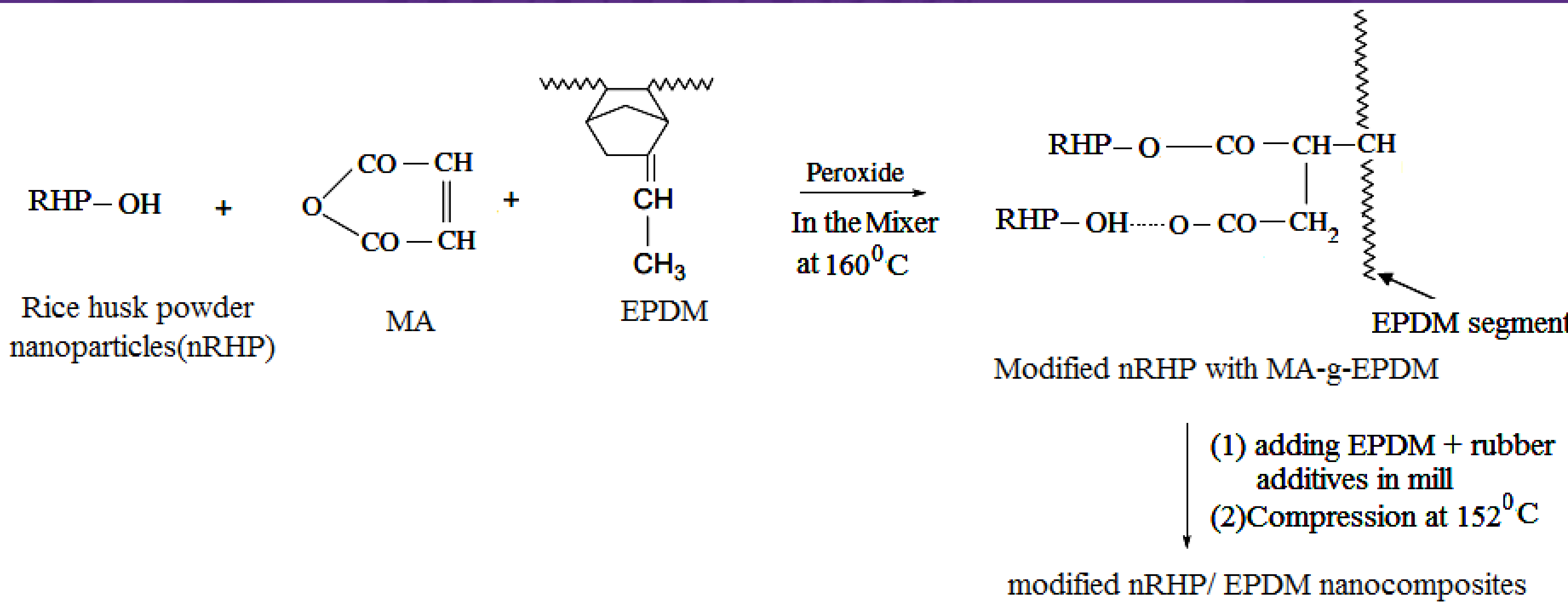
Using high energy ball mill to obtain nano size particles from RH (nRHP)

- RHP were grounded and sieved by using mechanical milling to nano-size scale.
- The aim of obtaining nano-size is to improve nanofiller-matrix interface adhesion and providing effective load-transfer from the matrix to the nanofillers. hence the resulting nanocomposites will have multifunctional characteristics for being used in different applications.

Surface treatment to nRHP

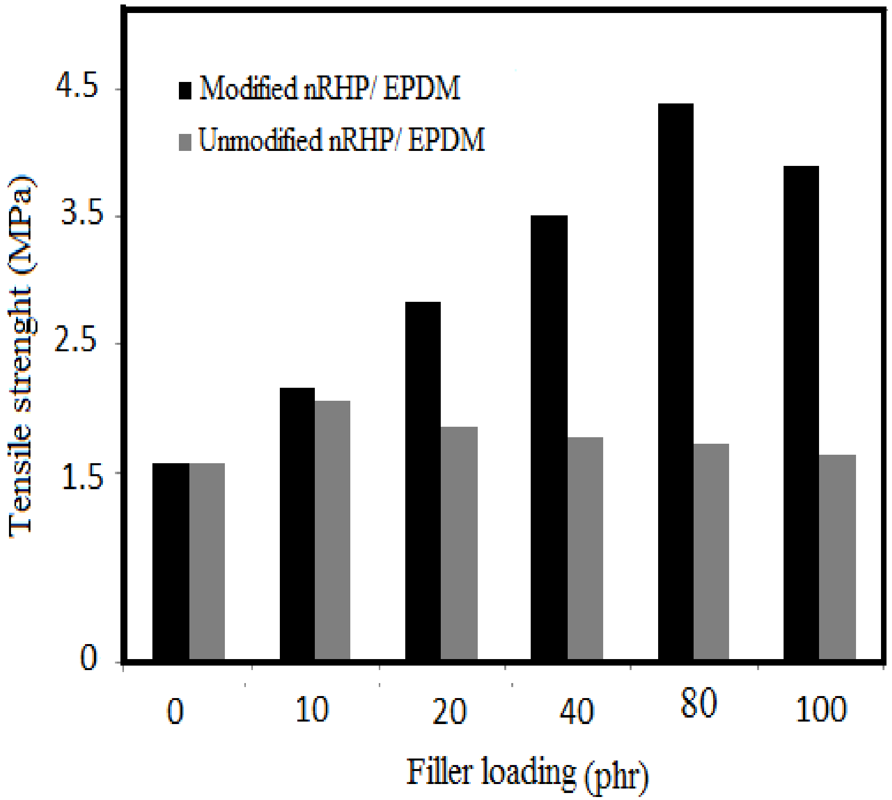
- Different surface treatment are used to improve the dispersion of nRHP into polymeric materials as EPDM matrix such as:
  1. Surface grafting of nRHP by using
     a) Copolymer from maleic anhydride and EPDM(MA-g-EPDM)
     b) hyperbranched polymer.
  2. Using a compatibilizer (maleated EPDM),
  3. Using HRH bonding system.

1- surface treatment by grafting nRHP with a copolymer from maleic anhydride and EPDM(MA-g-EPDM)

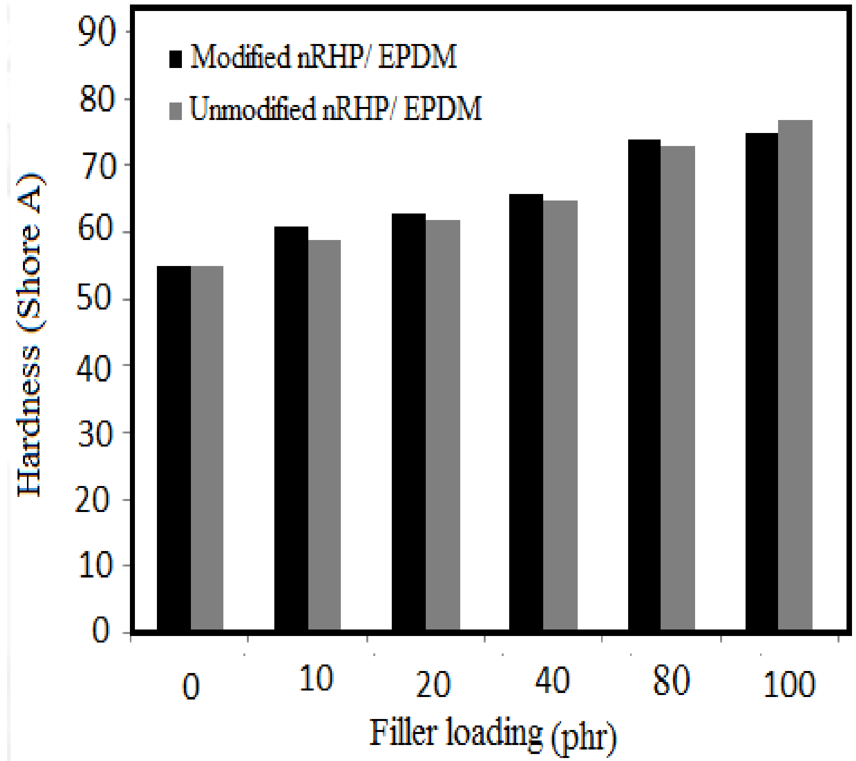


Scheme 1. Preparation of modified nRHP/ EPDM nanocomposites .

- The pre-treatment of nRHP with copolymer (MA -g- EPDM)in treated nRHP / EPDM nanocomposites gave better mechanical properties than untreated nanocomposites and this attributed to presence the copolymer (MA -g- EPDM)that increases the hydrophobicity and compatibility between nano rice husk powders and EPDM matrix .



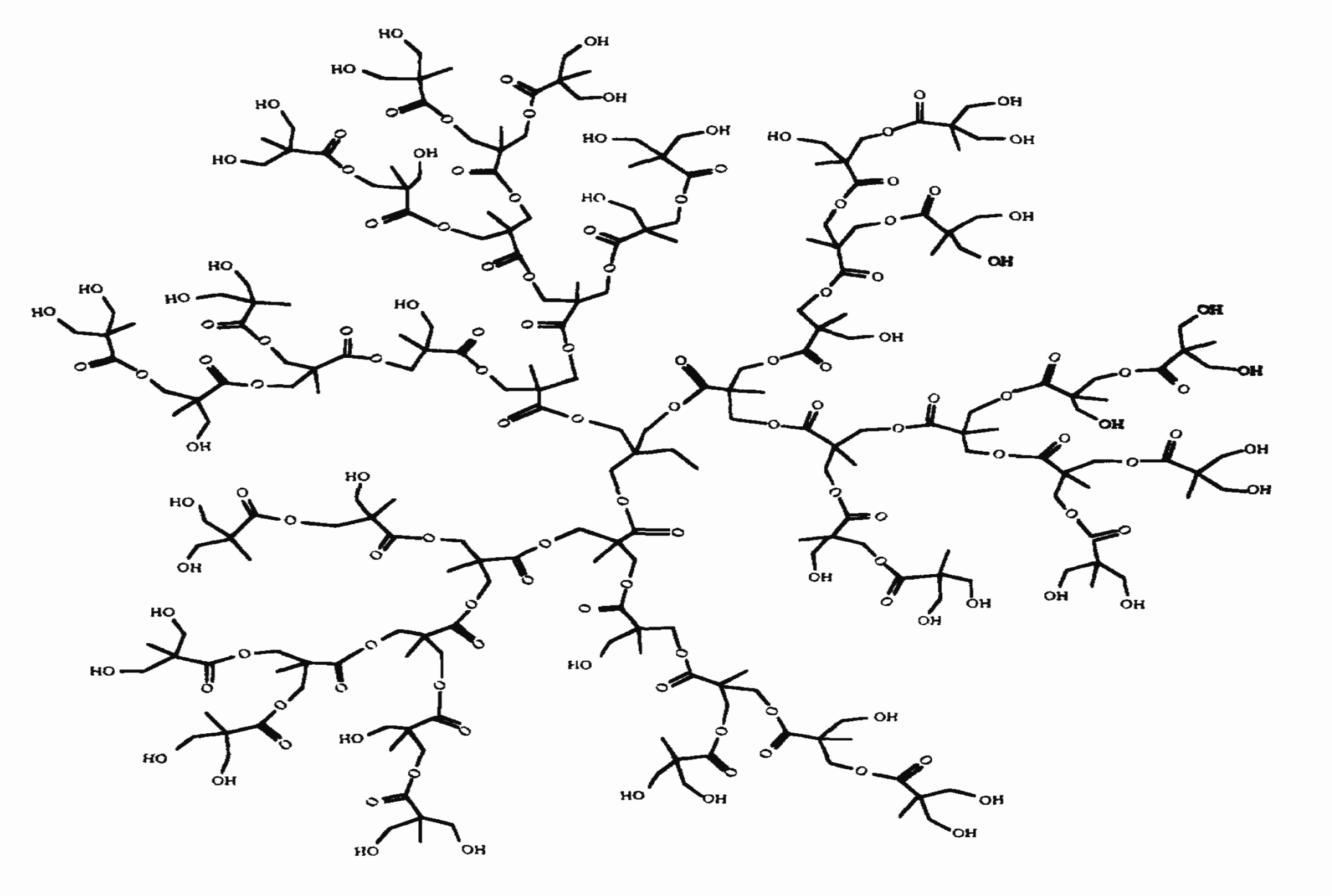
Effect of filler loading on the tensile strength of modified and unmodified nRHP/ EPDM nanocomposites .



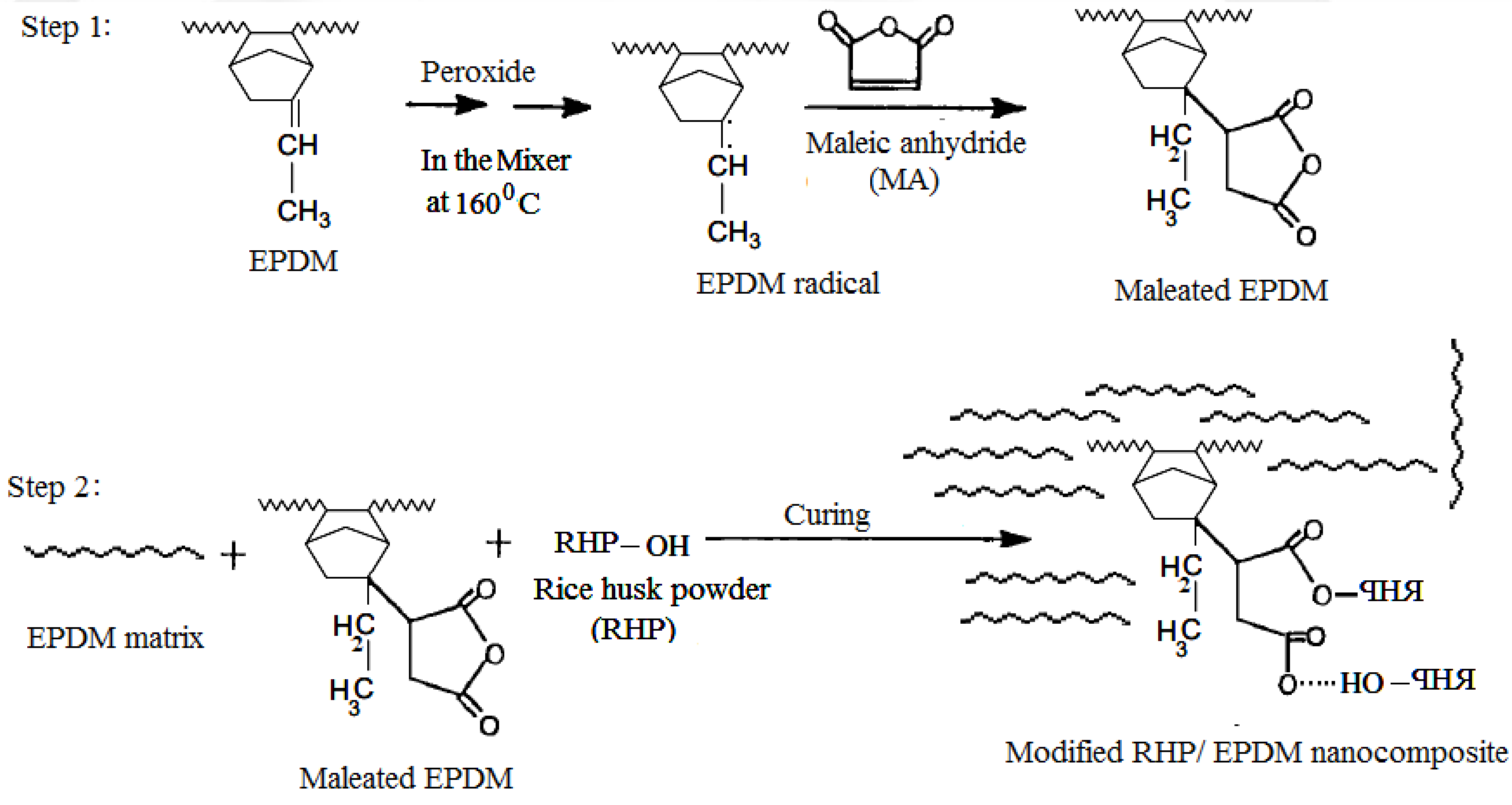
Effect of filler loading on the hardness of modified and unmodified nRHP/ EPDM nanocomposites .

- **The cytotoxicity of the resulting nano composites were studied by using MTT assay . The in vitro study indicated that the prepared nanocomposites are non-toxic materials for Human gingival fibroblat.**

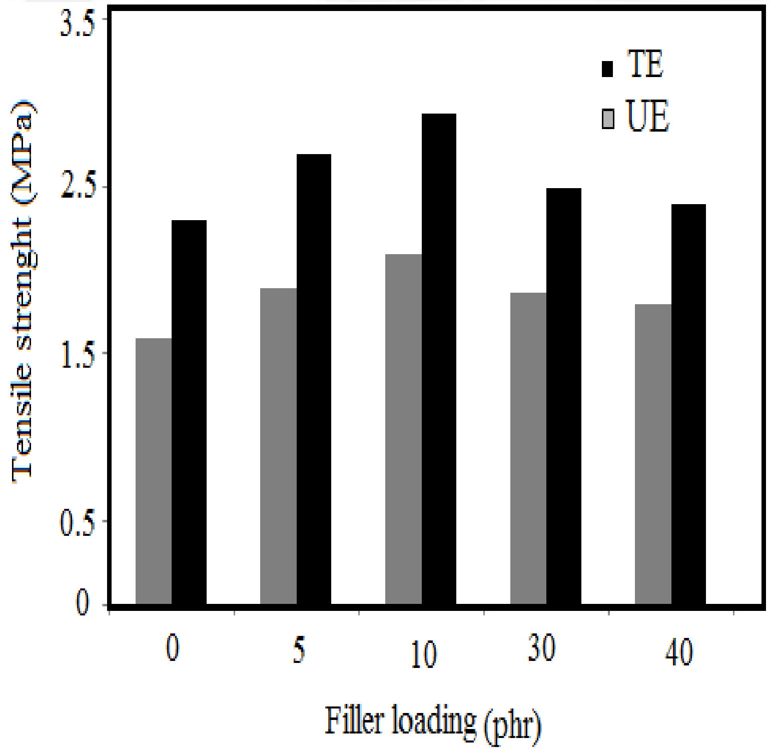
1- surface treatment by grafting nRHP with hyperbranched polymer



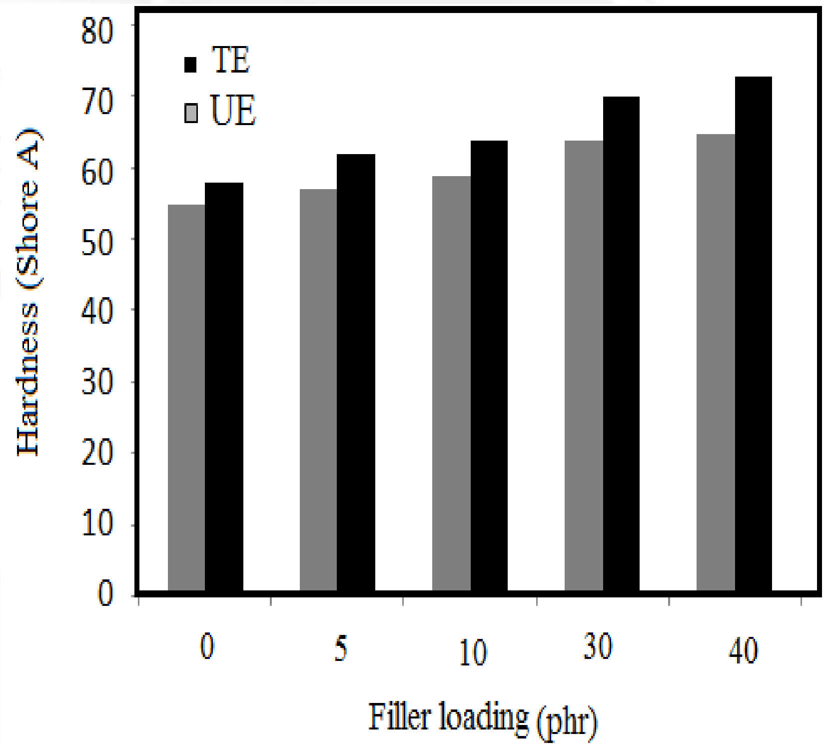
2- surface treatment by using compatibilizer (maleated EPDM)



- At similar filler loading the modified nanocomposites exhibit higher tensile strength compared to the unmodified nanocomposites which can be attributed to the presence compatibilising material (MA-g-EPDM) in modified one which enhance the dispersion of nRHP in EPDM matrix.
- At similar nRHP loading the hardness of modified is higher than the unmodified one.



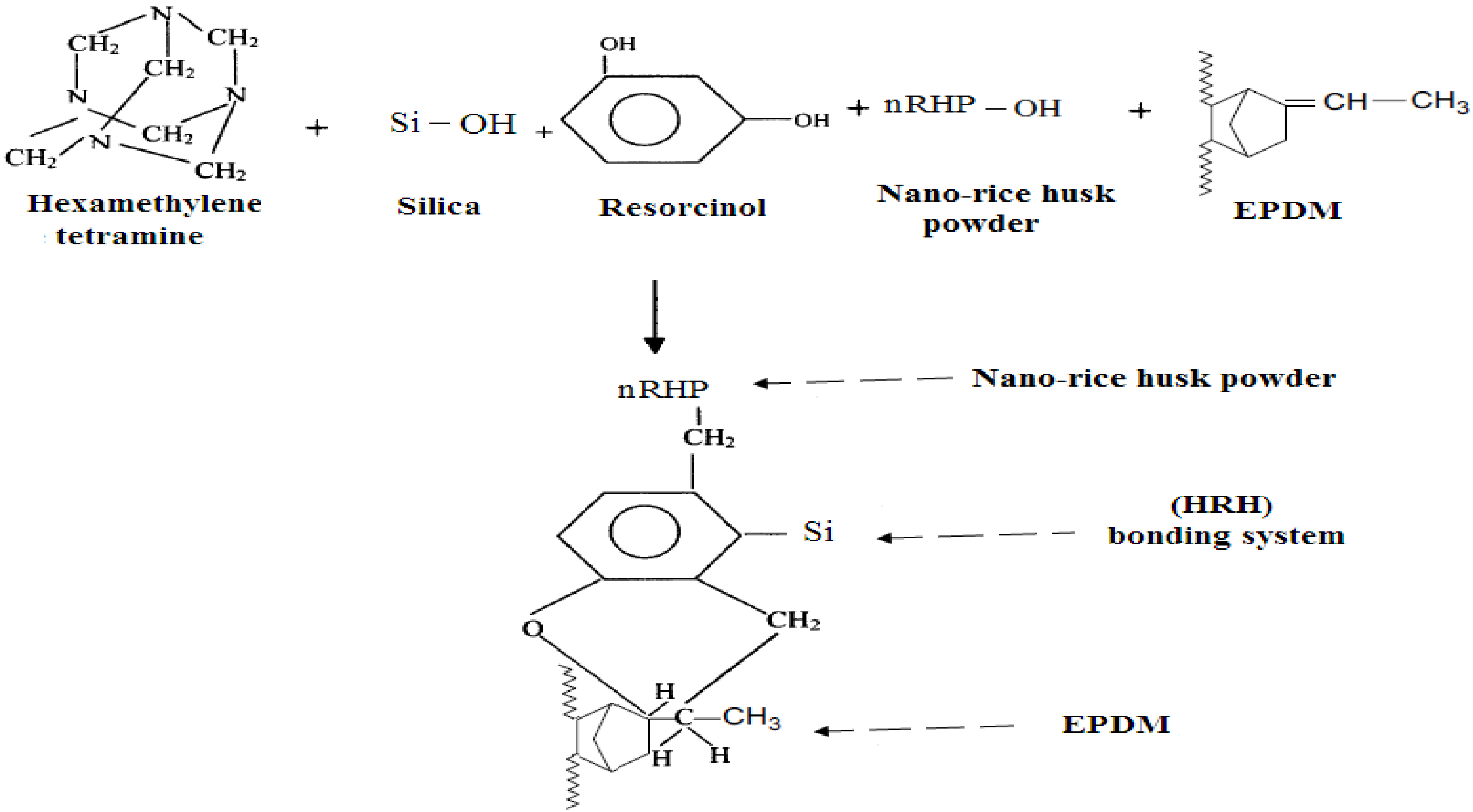
Tensile strength of treated and untreated nanocomposites at different filler loading



Hardness of treated and untreated nanocomposites at different filler loading.

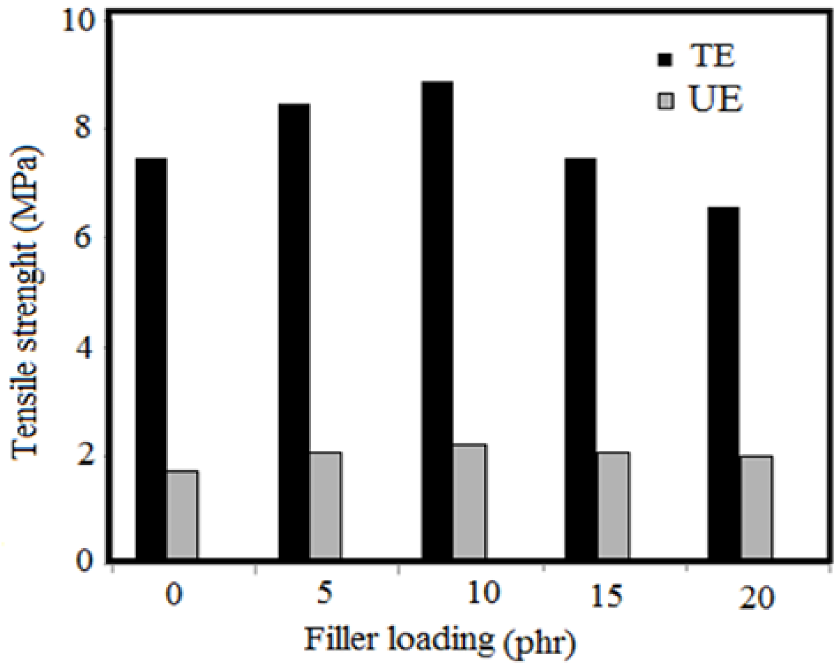
- **Compared with the above results, inserting compatibilizing material (MA-g-EPDM) in nRHP/EPDM nanocomposites have confirmed its effectiveness in improving adhesion and hence providing stress transfer from the matrix to the filler.**

Surface treatment by using dry bonding agent from hydrated silica, resorcinol and hexamethylene tetramine (HRH system)

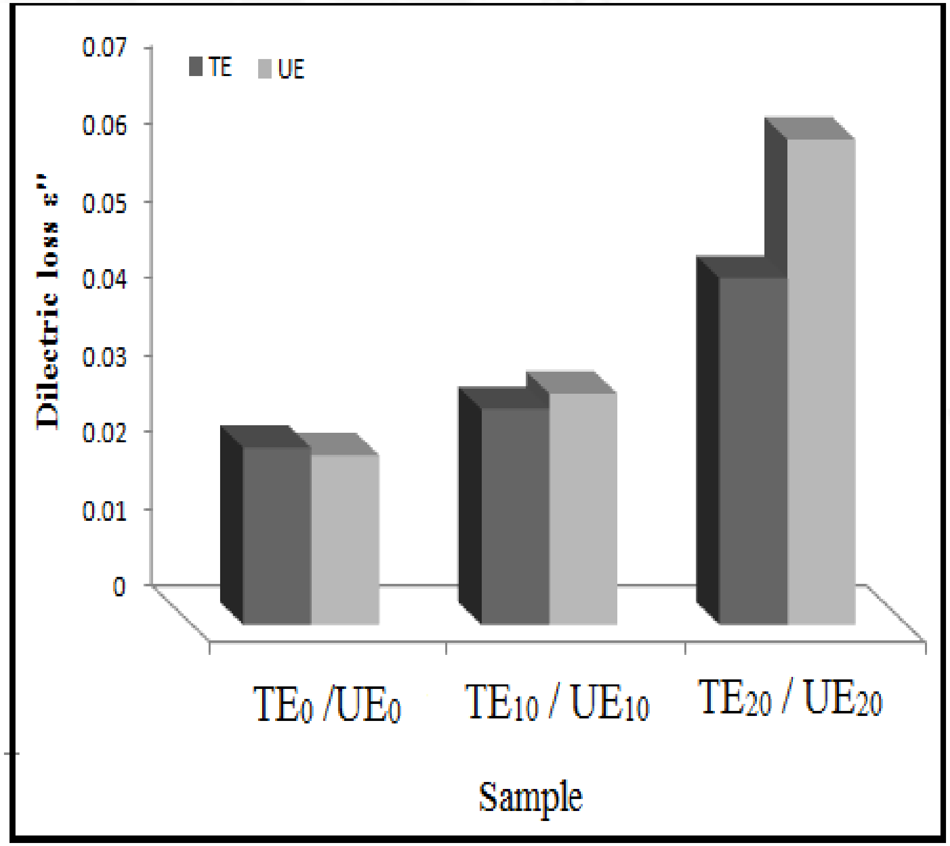


Scheme 1 : Mechanism of adhesion between nRHP and rubber matrix by using HRH system

- The dry bonding system causes significant improvement in the mechanical and dielectric properties of the EPDM/nRHP nanocomposites than that prepared without bonding agent. This indicates that HRH system produced good interfacial adhesion between nRHP and the rubber matrix.



Tensile strength of treated and untreated nanocomposites at different filler loading



Effect of filler loading on the dielectric loss of treated and untreated EPDM nanocomposites with HRH system.

- **The mechanical treatment with chemical treatments improved reinforcement efficiency of nanosized rice husk powder which was translated into better mechanical, thermal and morphological properties of nRHP/EPDM nanocomposites. The treatment increased the interfacial interactions between the filler and matrix phase.**

THANK YOU