Novel Cellulose Nanoparticles for Potential Pharmaceutical & Personal Care Applications

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OUTLINE

- POLYAMPHOLYTE MICROGELS
  - INTRODUCTION
  - CHARACTERIZATION RESULTS
- NANO CRYSTALLINE CELLULOSE
  - INTRODUCTION
  - BINDING INTERACTION STUDIES
- FUTURE WORK
- SUMMARY

CHITOSAN - CARBOXYMETHYL CELLULOSE POLYAMPHOLYTE MICROGELS

POLYAMPHOLYTE MICROGELS

POLYAMPHOLYTES

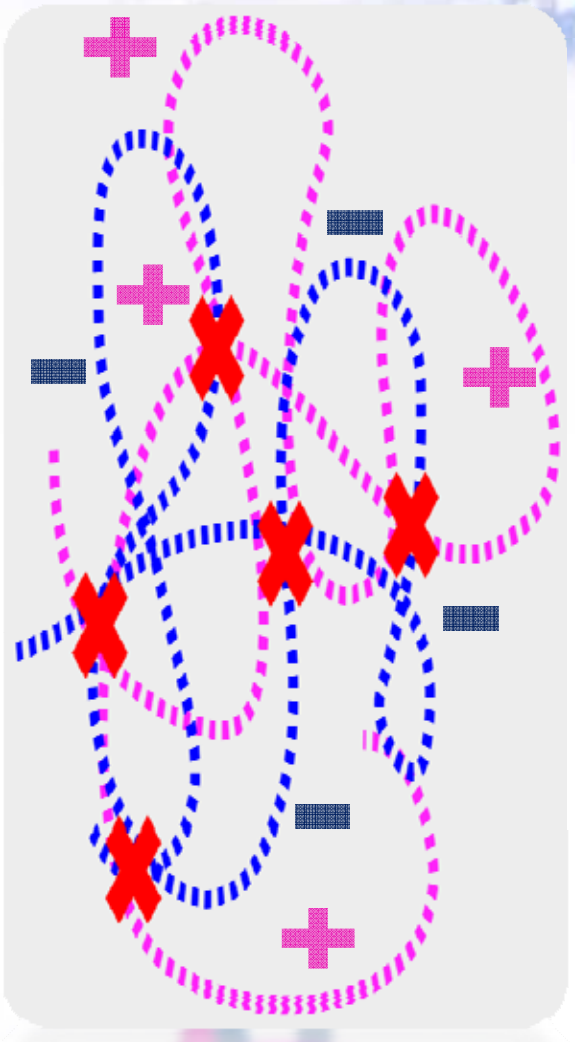
Polymers consisting of positive and negative charges

MICROGELS

Crosslinked polymer particles

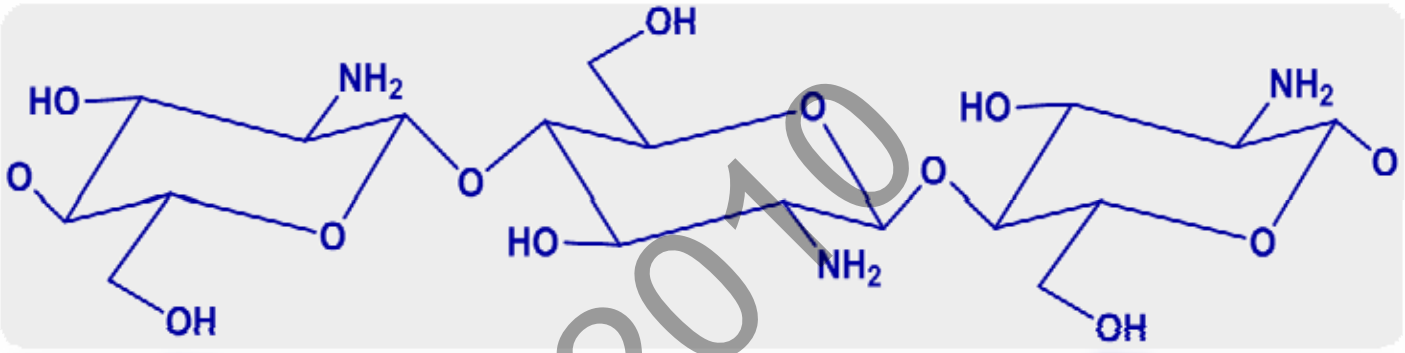
POLYAMPHOLYTE MICROGELS

Crosslinked particles capable of possessing positive and negative charges

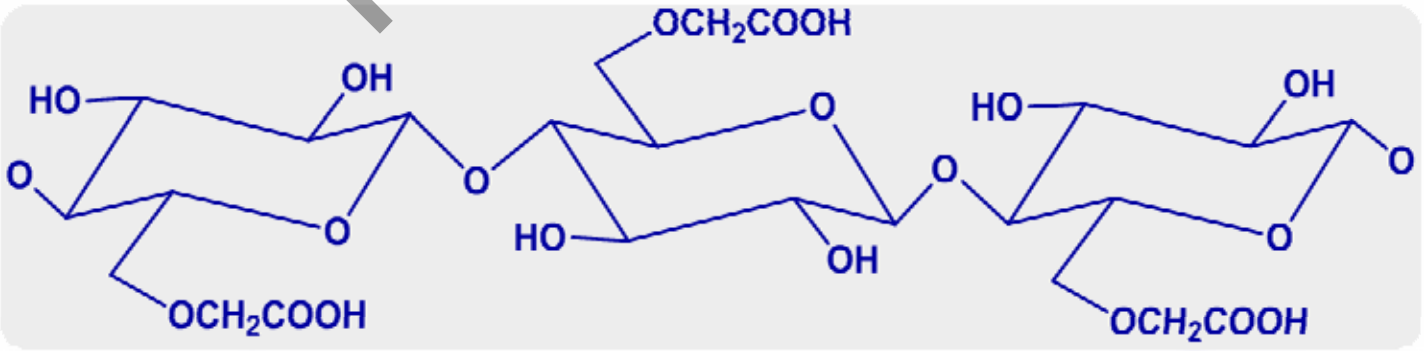


PROPOSED SYTEM

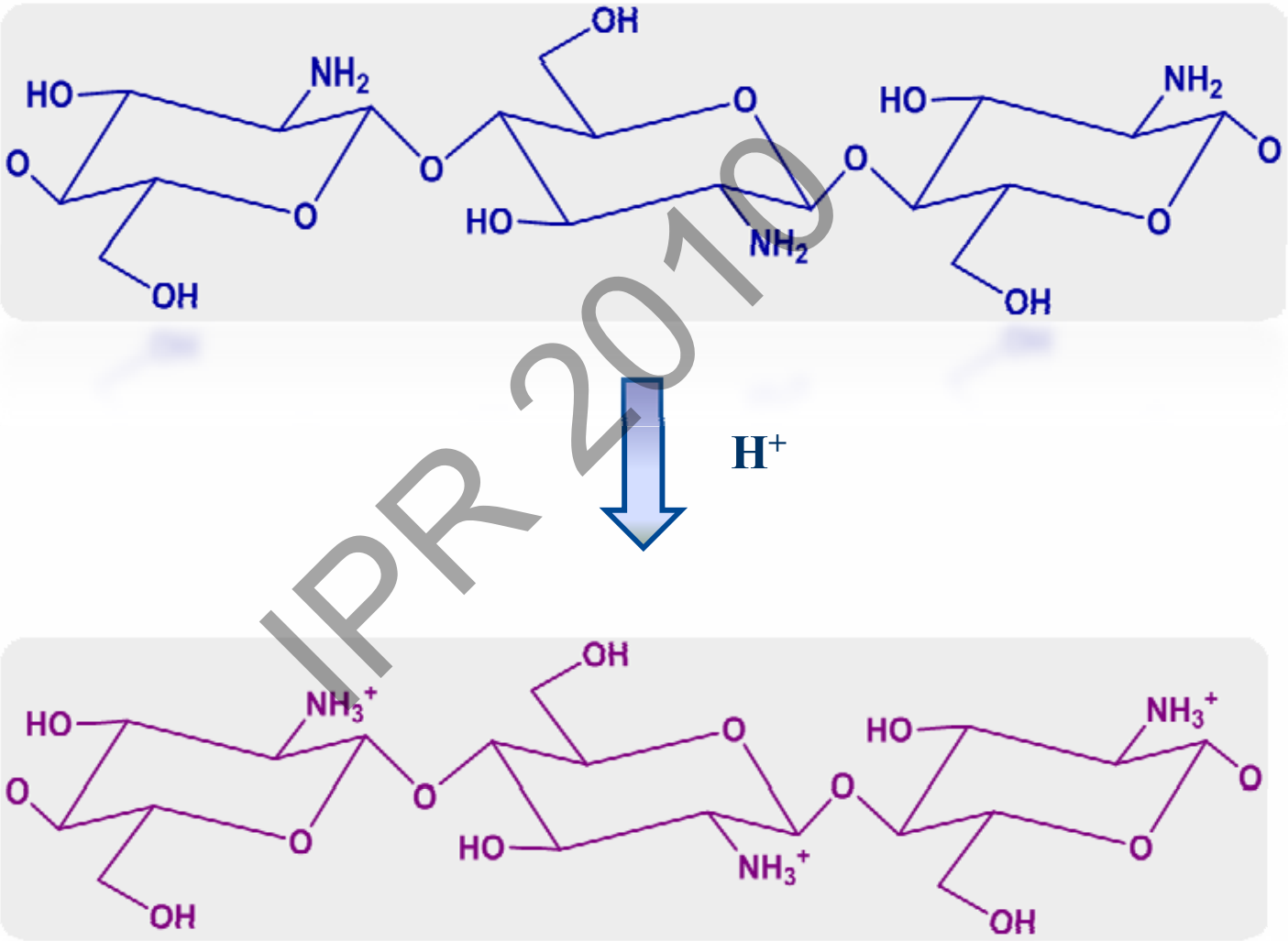
CHITOSAN



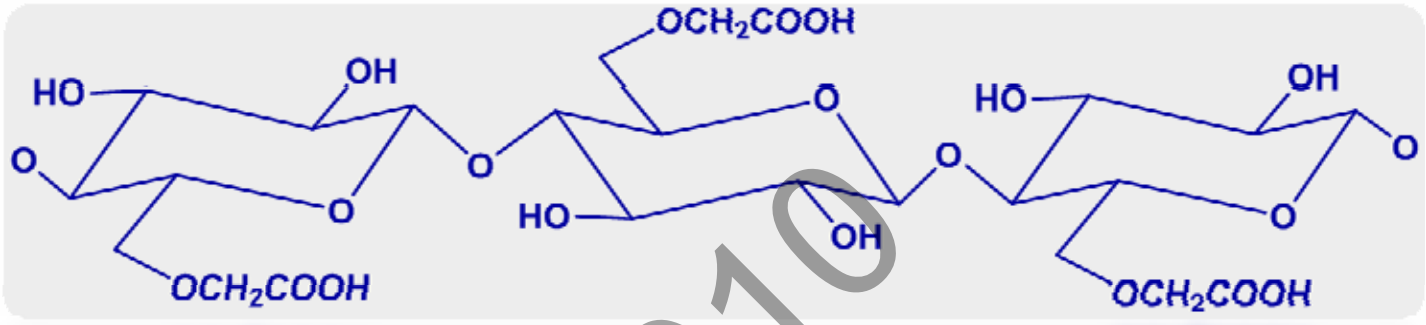
CARBOXYMETHYL CELLULOSE



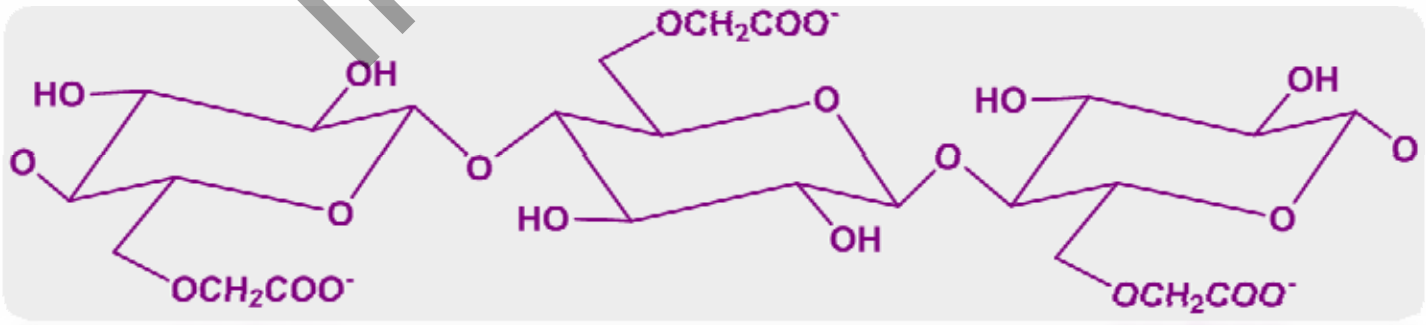
CHITOSAN AT LOW pH



CARBOXYMETHYL CELLULOSE AT HIGH pH



OH^-



SYNTHESIS TECHNIQUE

INVERSE MICROEMULSION POLYMERIZATION

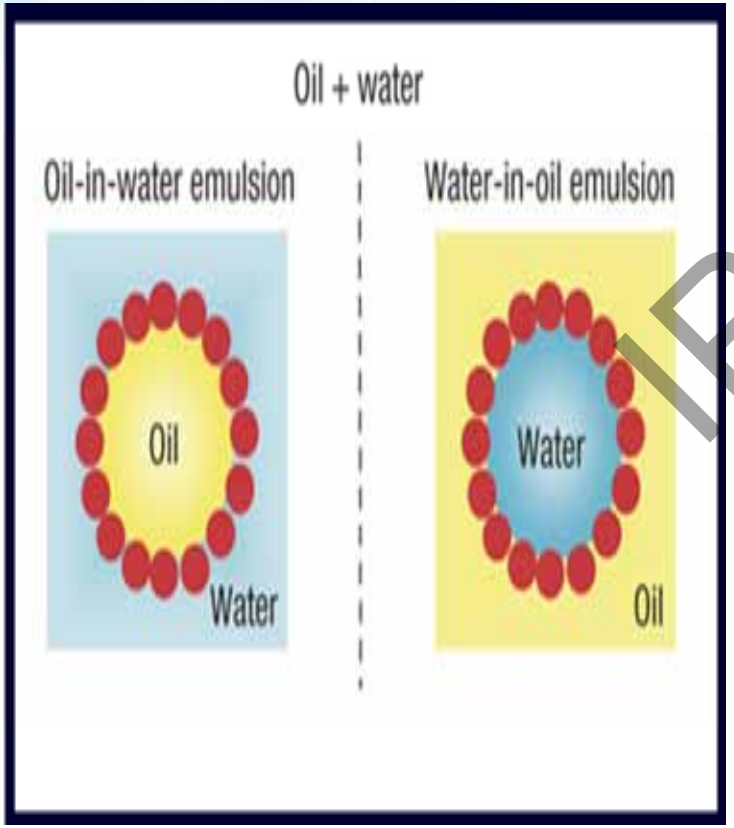
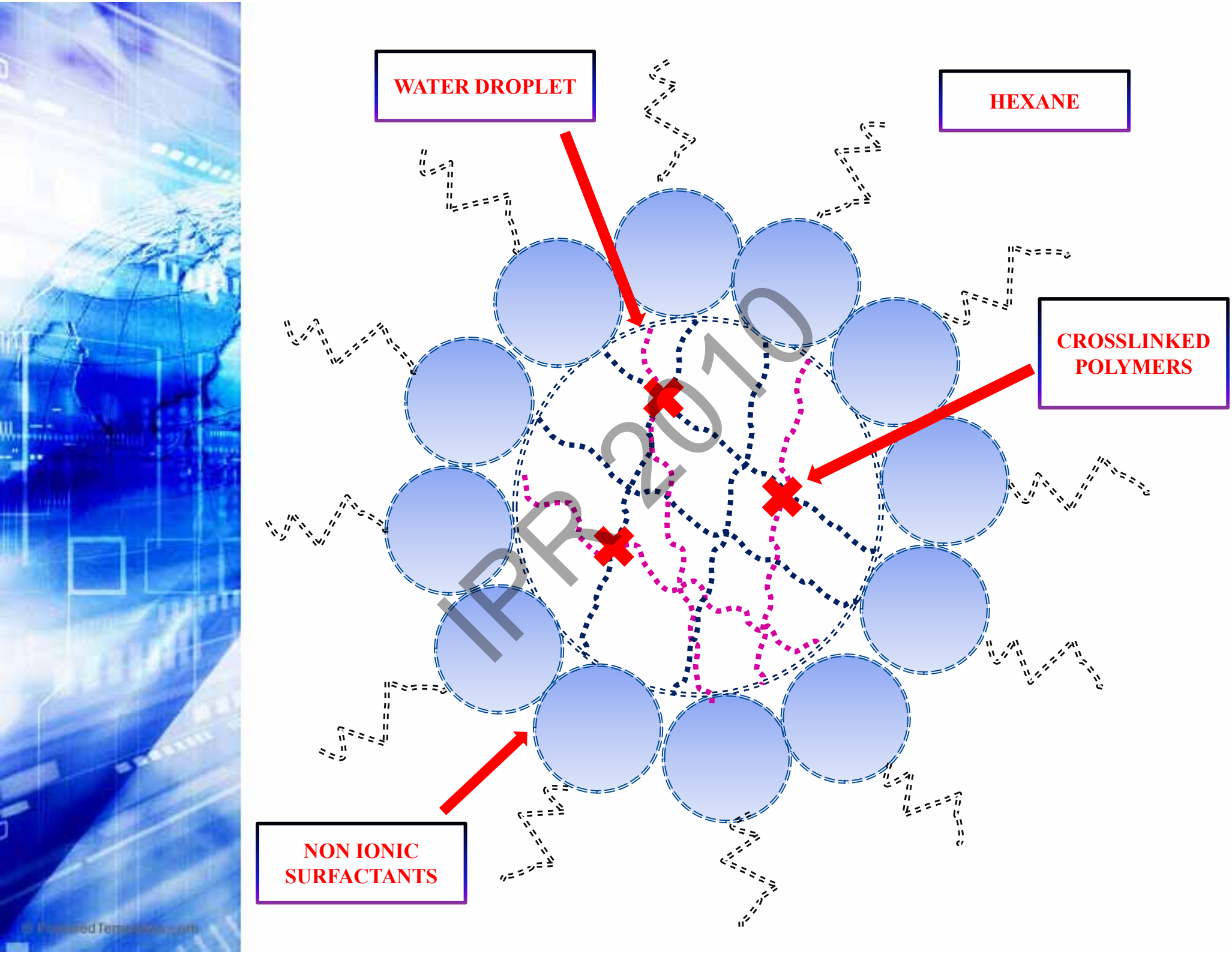


Image from http://www.nature.com/nmat/journal/v5/n11/fig_tab/nmat1757_f1.html

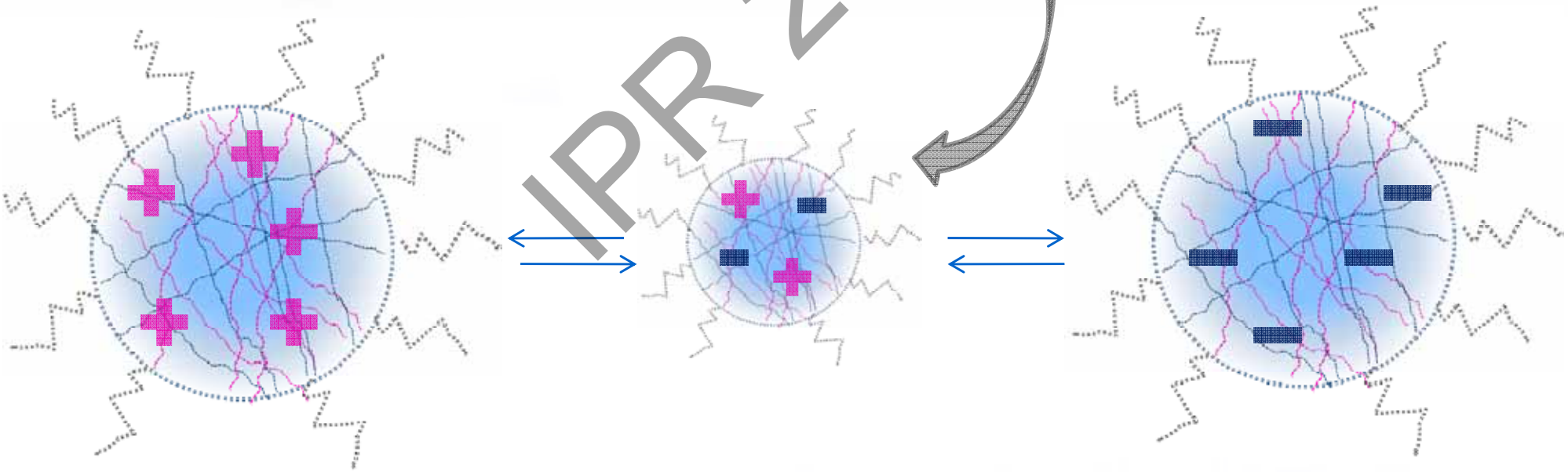
1. Thermodynamically stable microemulsions
2. Non ionic surfactants
3. W/O emulsions at high temperatures
4. Water droplets act as nano - reactors
5. Polymerization & Crosslinking in the water droplets
6. Beneficial for water soluble polymers


WATER DROPLET
HEXANE
CROSSLINKED POLYMERS
NON IONIC SURFACTANTS
IPR2010

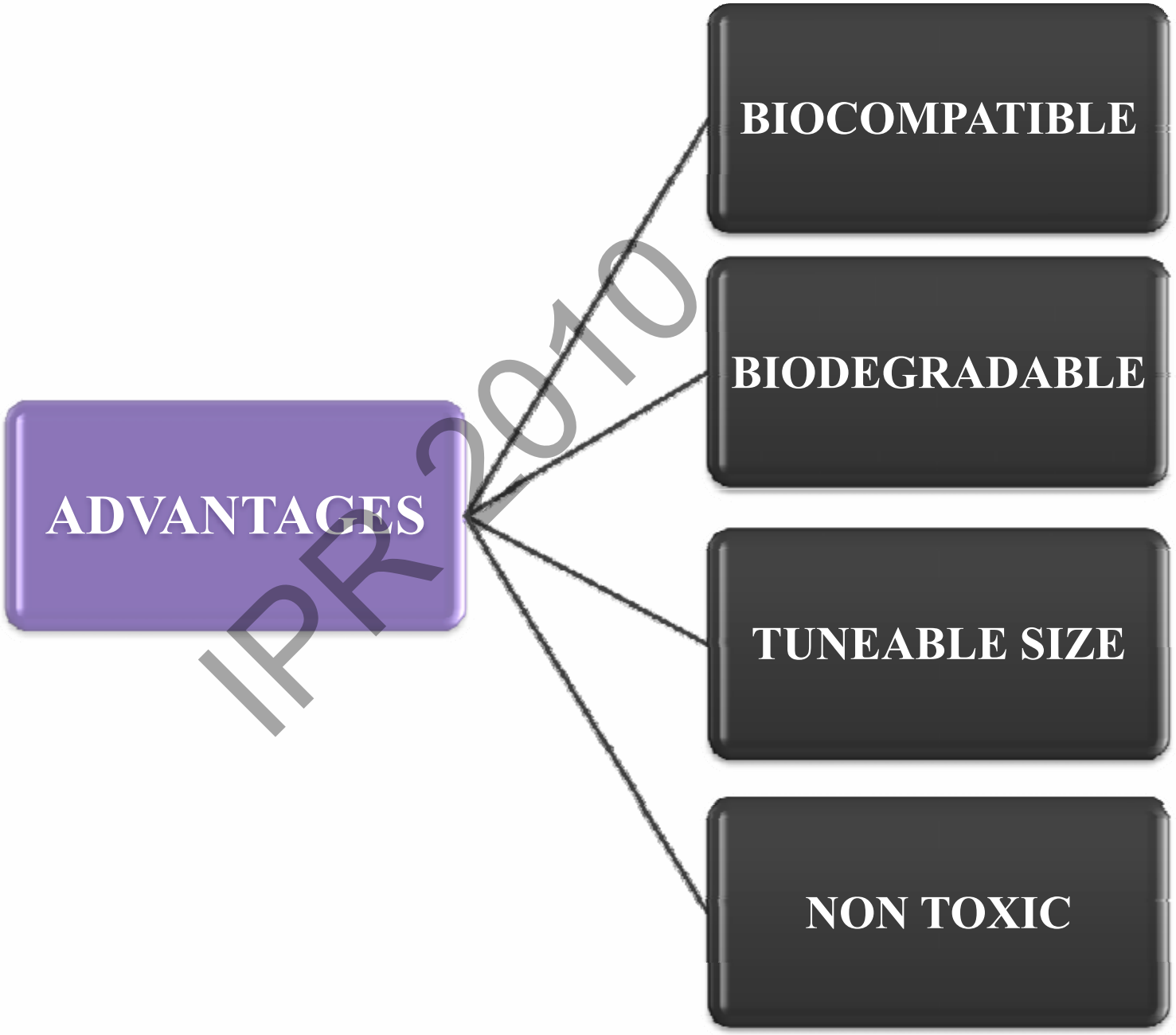
pH RESPONSIVE BEHAVIOR OF POLYAMPHOLYTE MICROGELS

Steric stabilization is important !

Microgel Swelling | Microgel Deswelling | Microgel Swelling



Low pH | Neutral pH | High pH

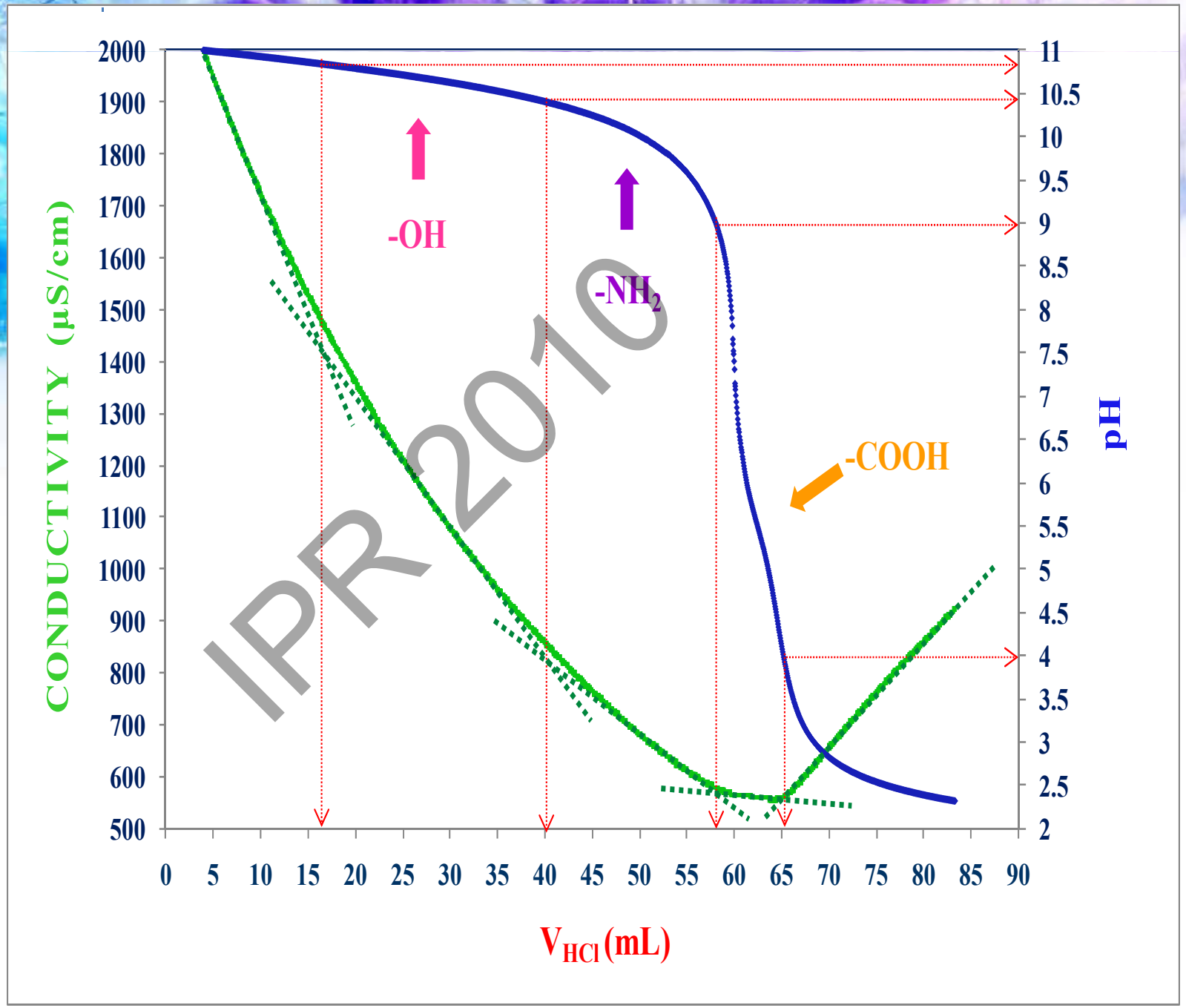

ADVANTAGES
BIOCOMPATIBLE
BIODEGRADABLE
TUNEABLE SIZE
NON TOXIC

CHARACTERIZATION RESULTS

- Potentiometric & Conductometric measurements
- Dynamic Light Scattering
- Zeta Potential measurements

POTENTIOMETRIC & CONDUCTOMETRIC TITRATION

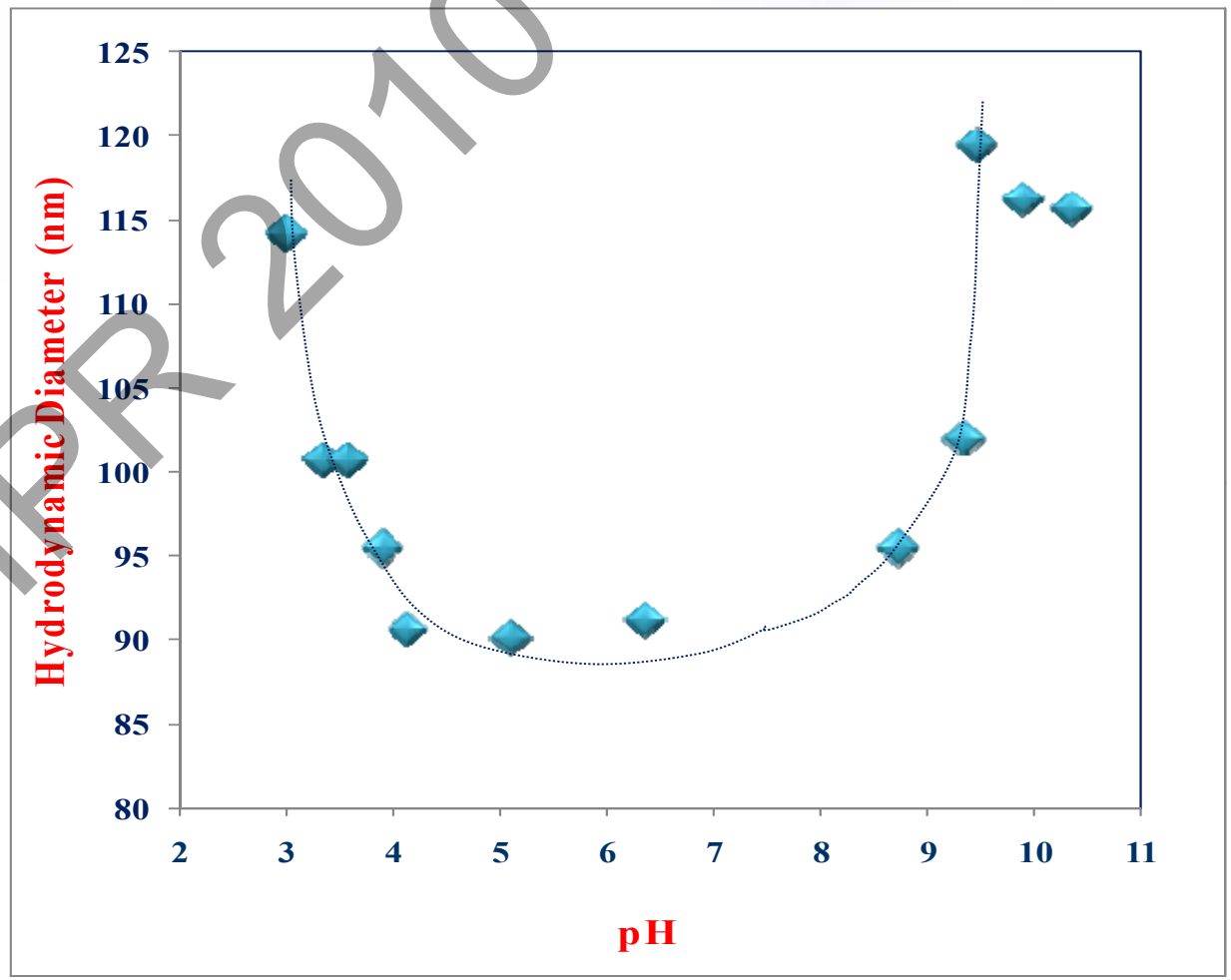
- Acid/Base Titrations
- Simultaneous measurement of pH & Conductivity



DYNAMIC LIGHT SCATTERING

- Principle of Light Scattering
- Hydrodynamic Radius

- Iso - electric point pH range 4 ~ 9
- Maximum swelling ~ 25 nm
- Swelling in a very narrow range of pH 3 ~ 4 & 9 ~ 10

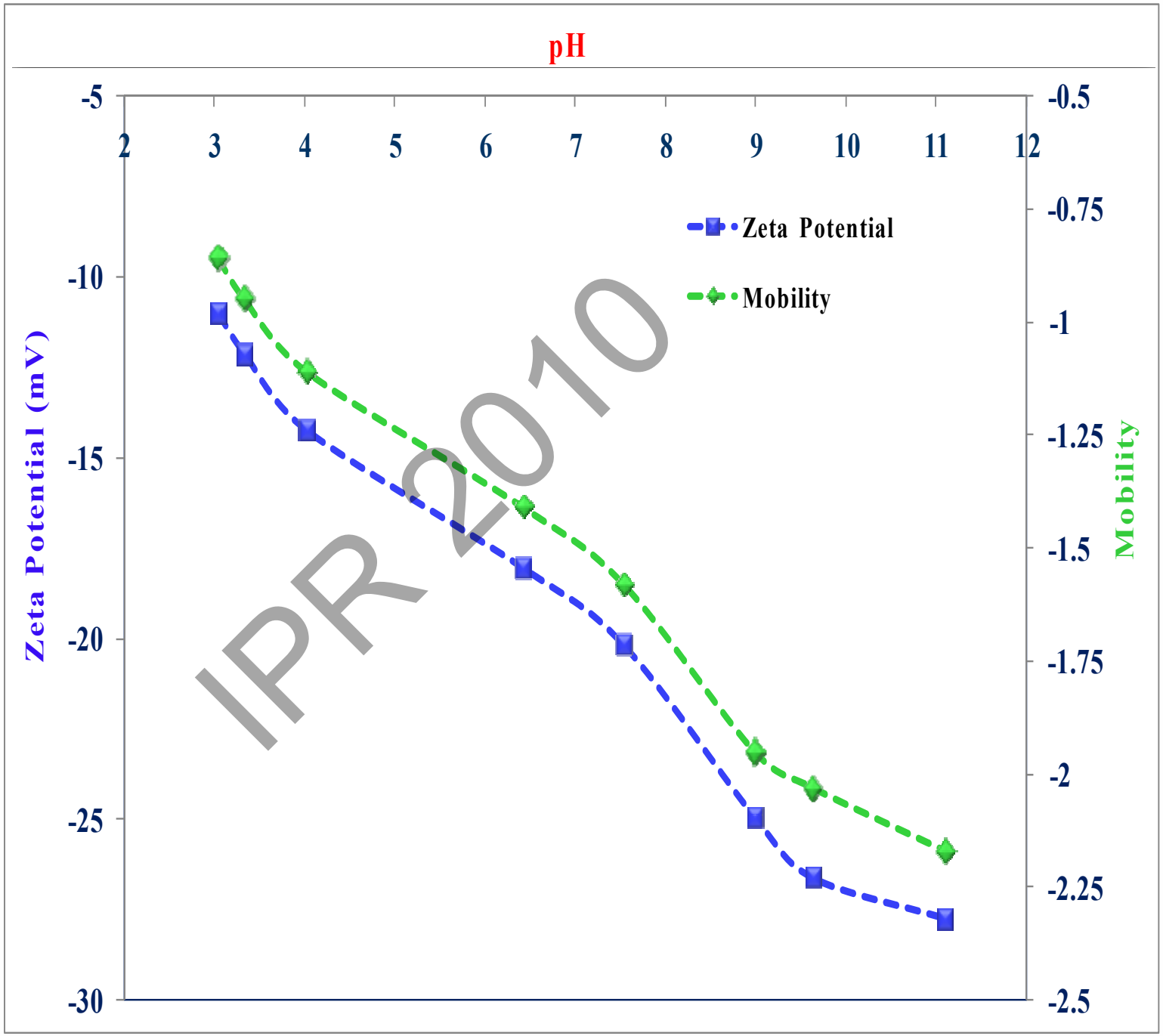


ZETA POTENTIAL MEASUREMENTS

- Potential difference between the medium and the stationary fluid layer around the particle

- Electrophoresis

Image from http://www.nbtc.cornell.edu/facilities/tools/Nano-ZS%20image.bmp


pH
Zeta Potential (mV)
Mobility
Zeta Potential
Mobility
-5
-10
-15
-20
-25
-30
-0.5
-0.75
-1
-1.25
-1.5
-1.75
-2
-2.25
-2.5
2
3
4
5
6
7
8
9
10
11
12
IPR 2010

NANO CRYSTALLINE CELLULOSE

INTRODUCTION

- Obtained from wood or cotton
- Acid hydrolysis with sulphuric acid
- Rod-like crystals
- L = 200 nm, D = 10 nm
- Biodegradable & Sustainable

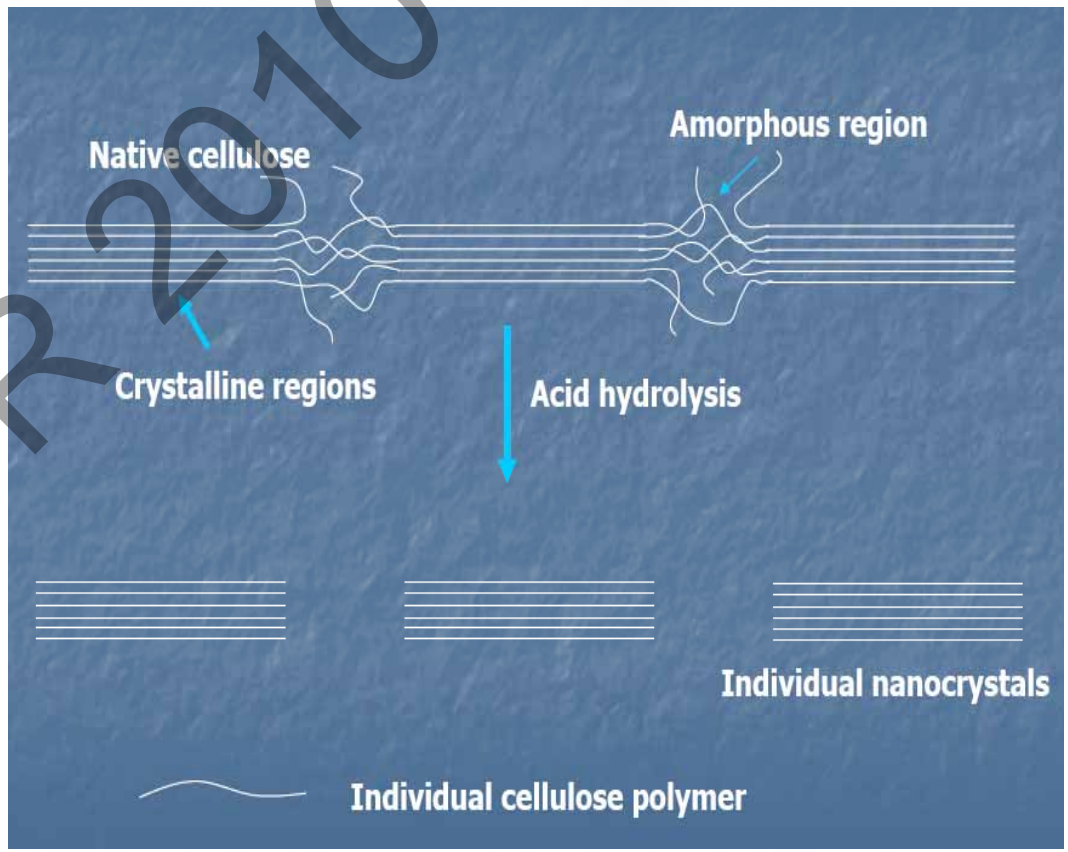
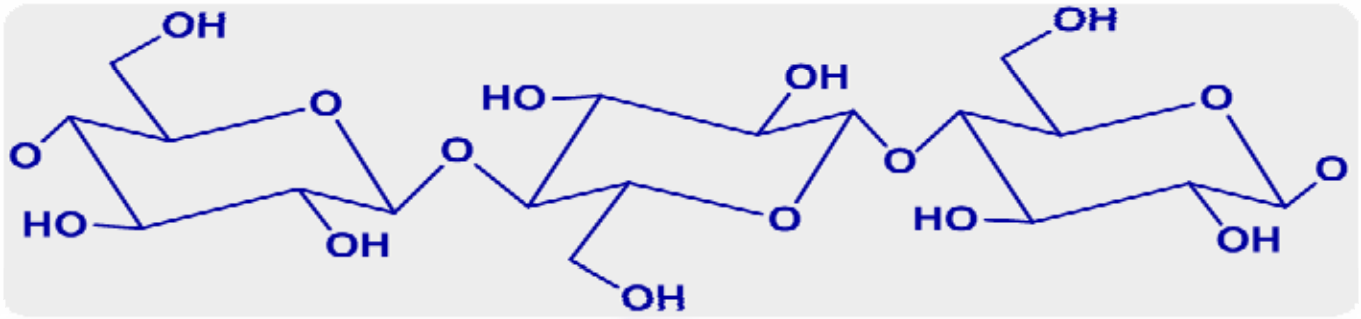
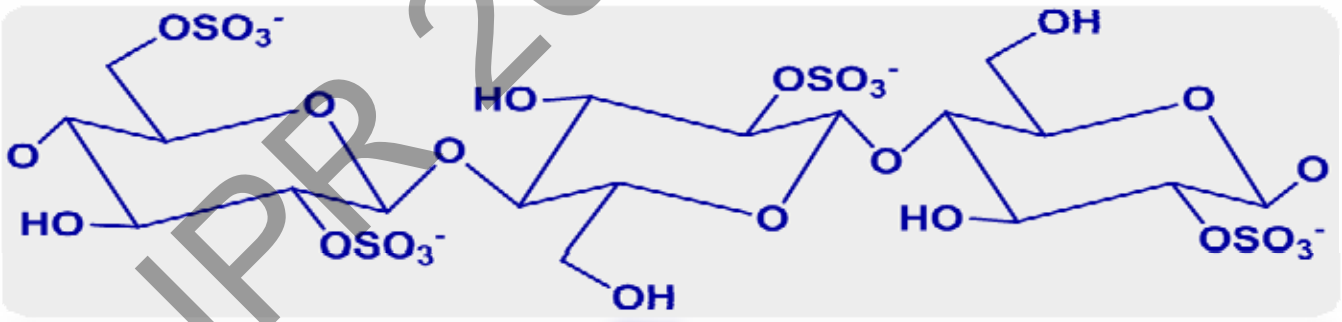
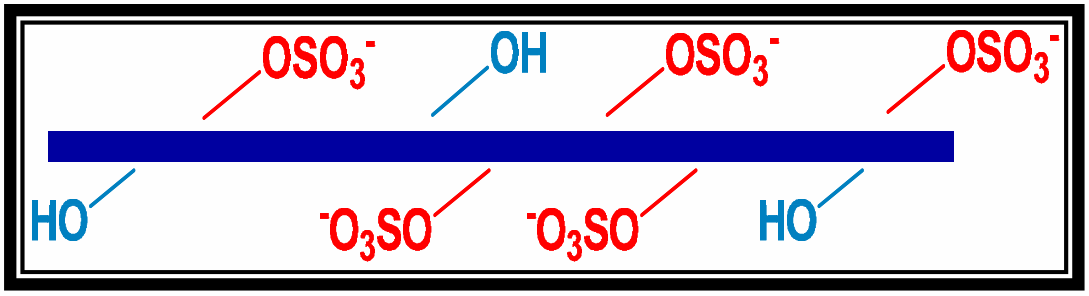


Image from http://forestproducts.orst.edu/faculty/simonsen/Nanocomposites.pdf



H_2SO_4





BINDING INTERACTION WITH SURFACTANT

FOR POTENTIAL PERSONAL HOME CARE APPLICATIONS

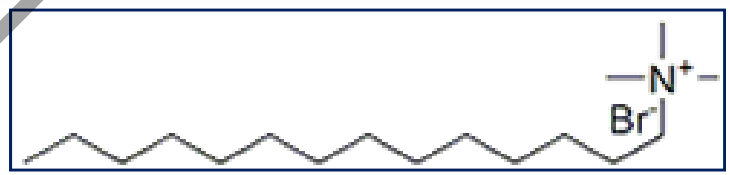
Isothermal Titration Calorimetry

- Binding interaction in bulk

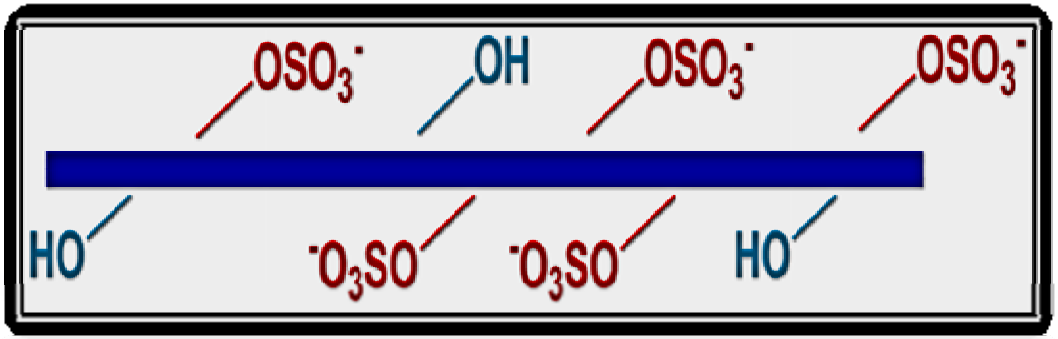
Surface Tensiometry

- Interaction at liquid-air interface

Tetradecyl Trimethyl Ammonium Bromide

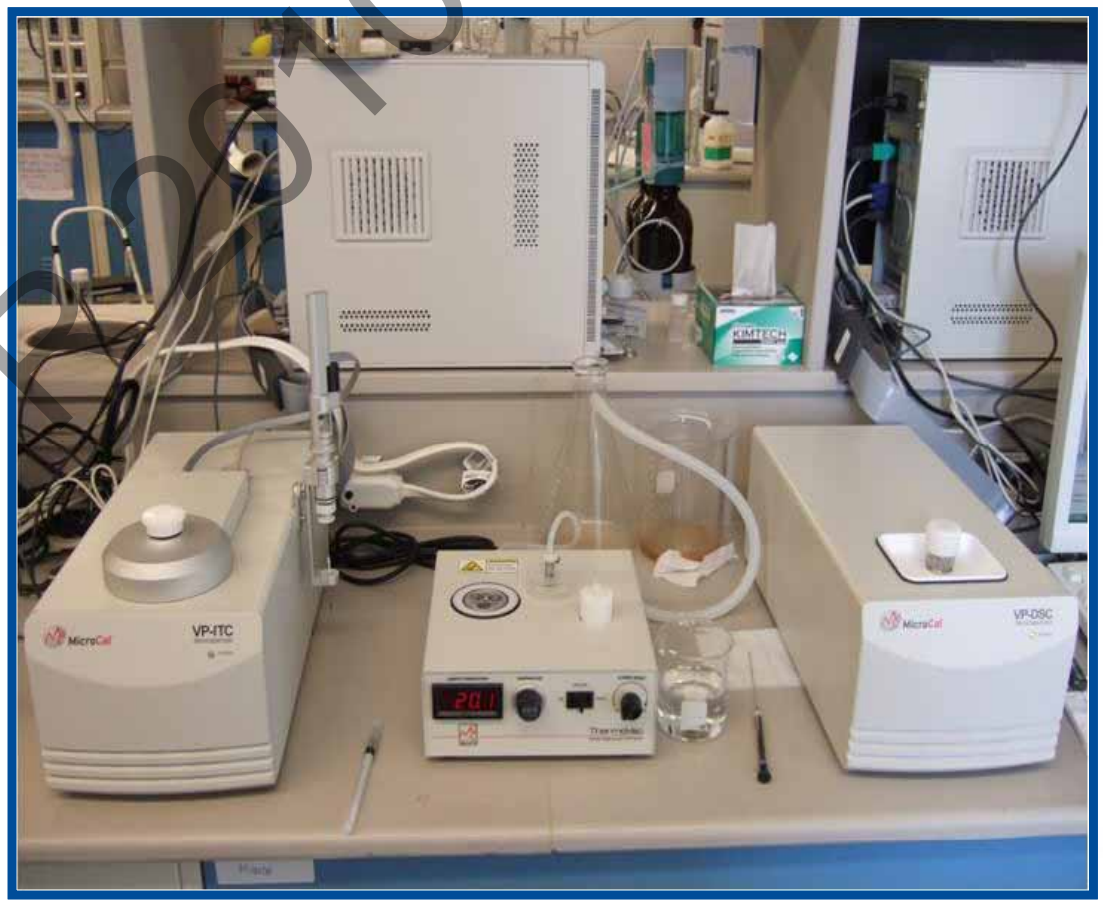


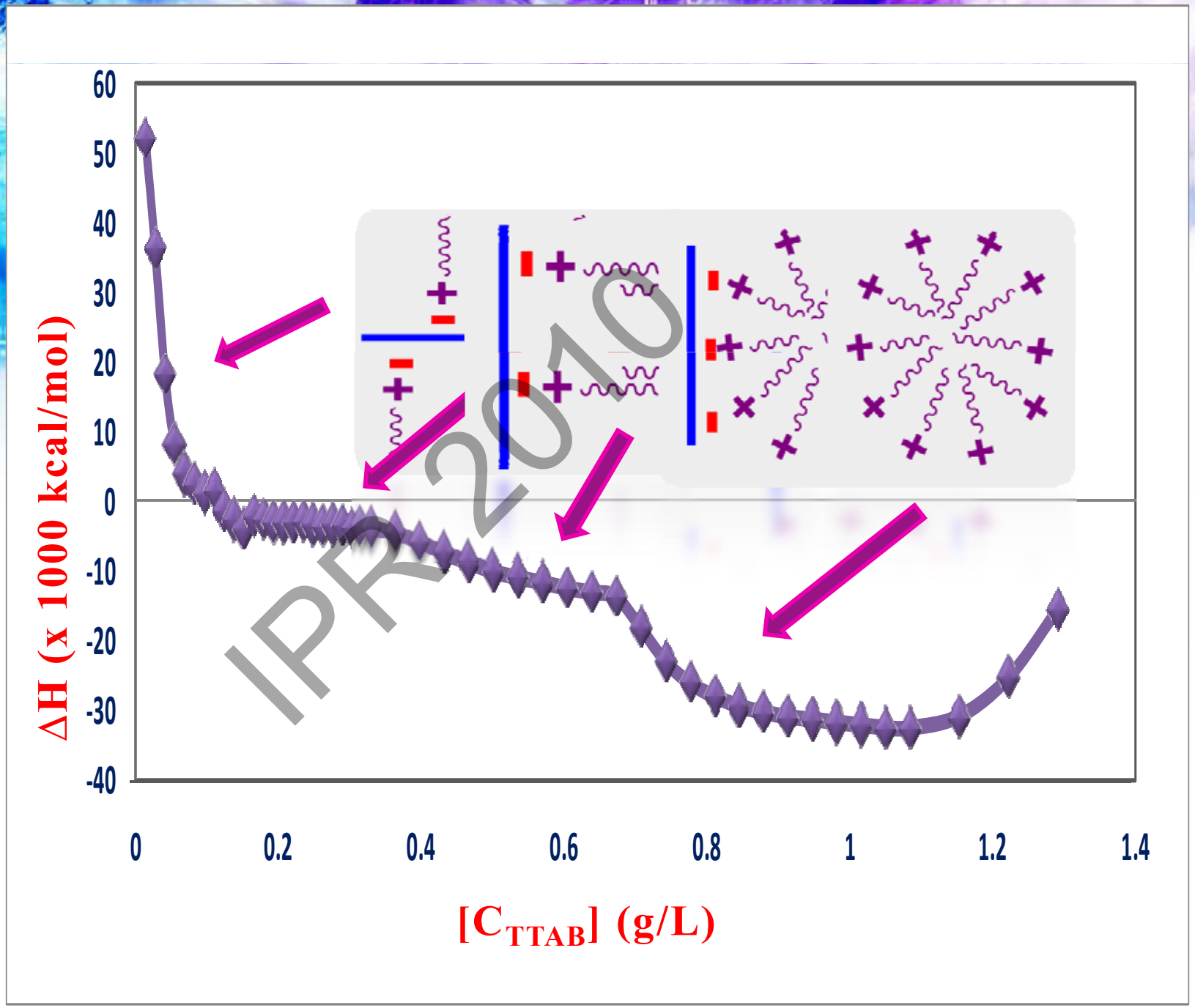
Nano Crystalline Cellulose



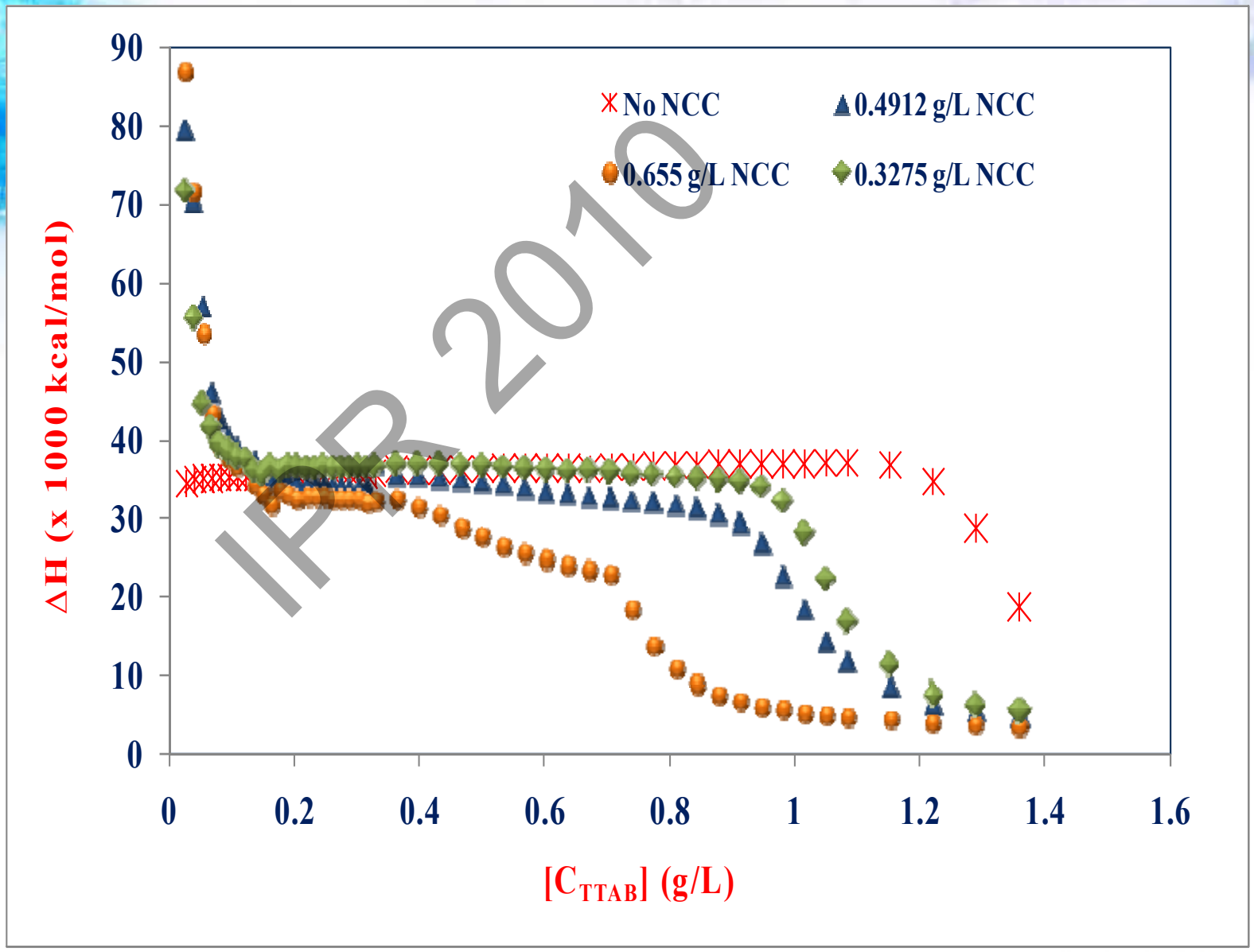
ISOTHERMAL TITRATION CALORIMETRY

- Thermodynamic heat changes during chemical interactions
- Binding of polymer and surfactant



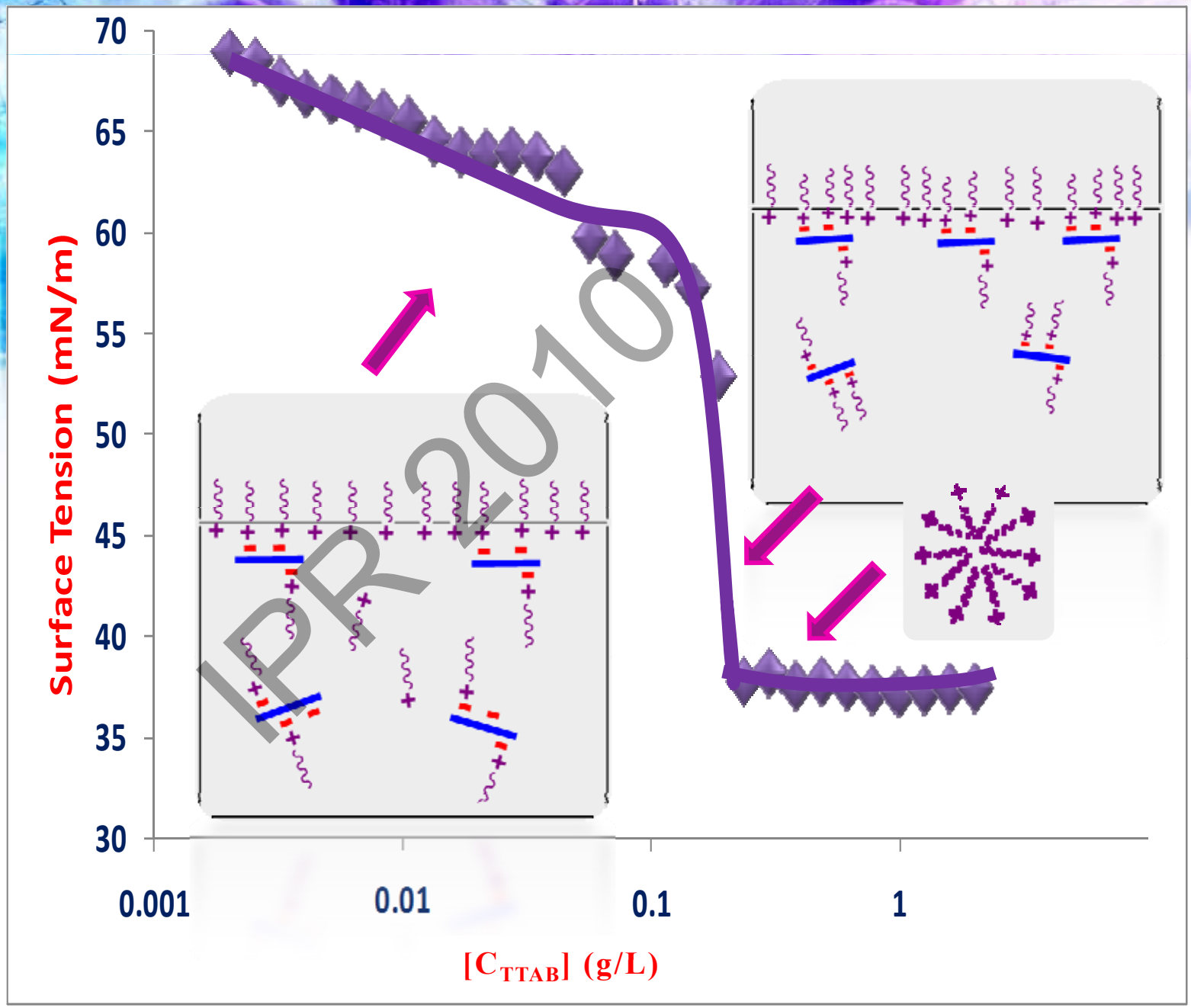


EFFECT OF NCC CONCENTRATION ON ITC CURVES

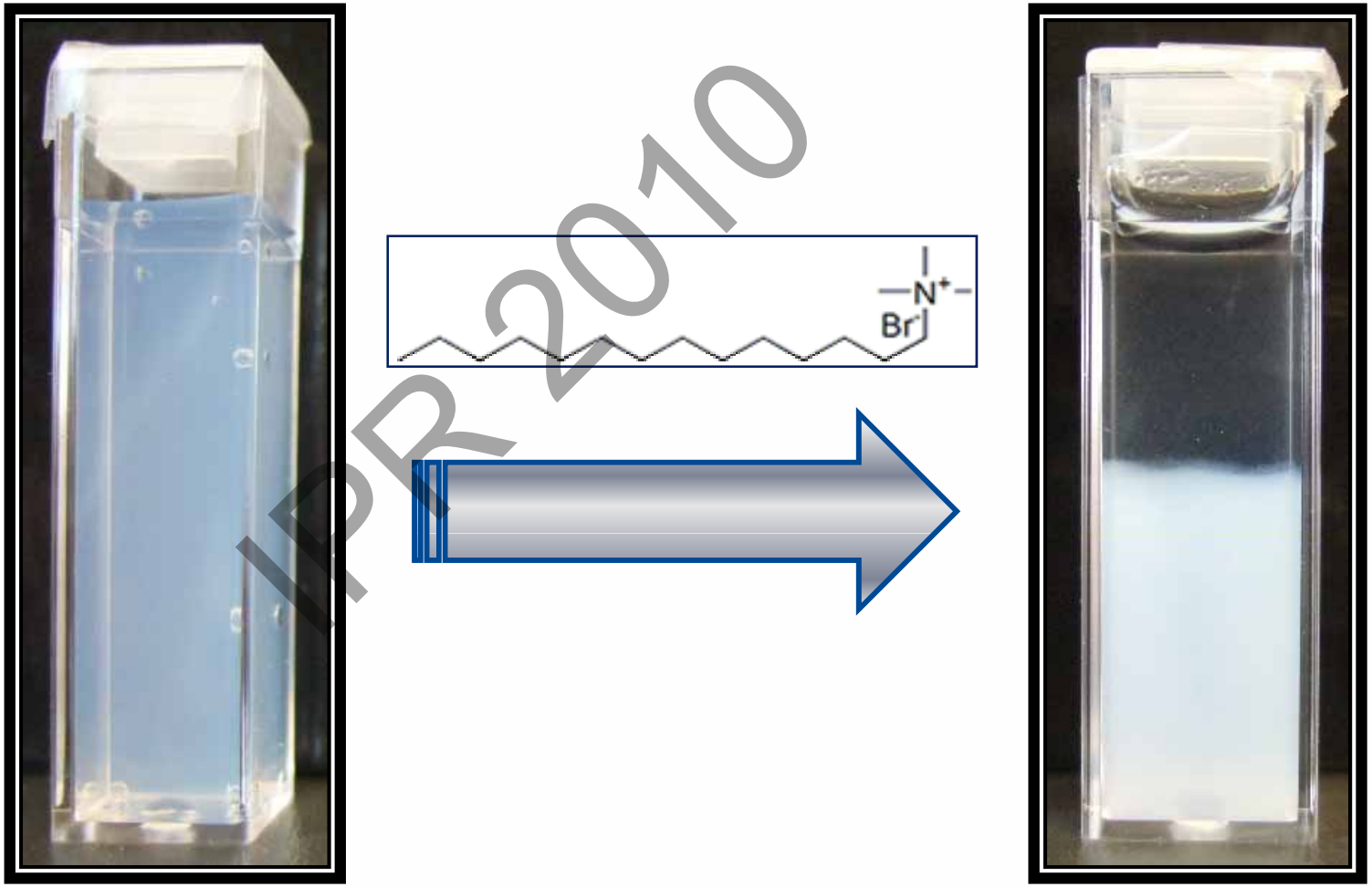


SURFACE TENSIOMETRY

- **Wilhelmy plate method**
- **Computer controlled dosing devices for precise titration of surfactants**

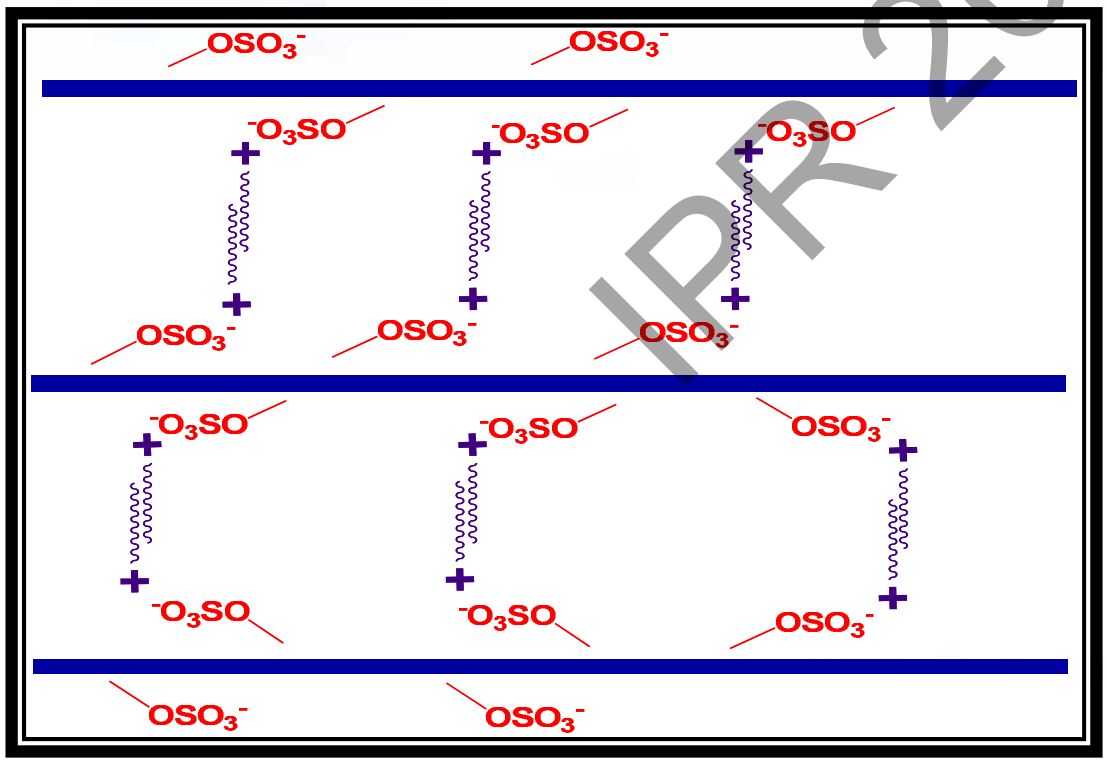


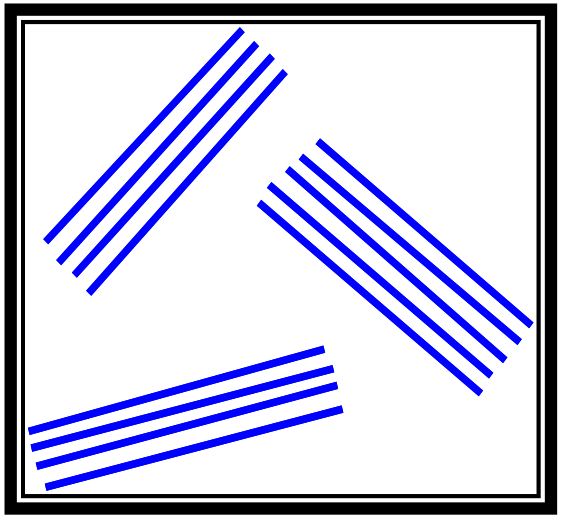
PHASE SEPARATION IN PRESENCE OF SURFACTANT



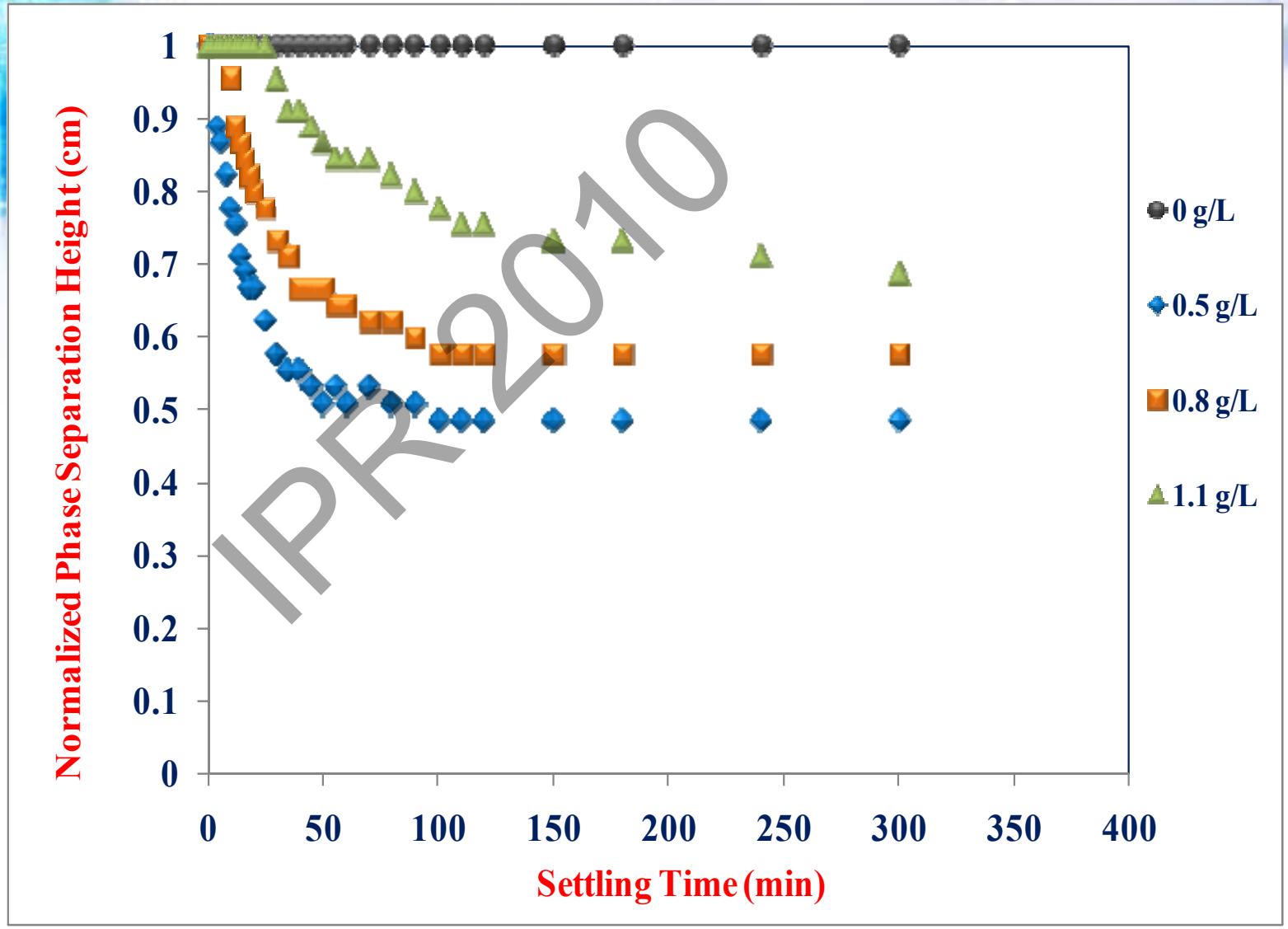
STACKING UP OF NANOCRYSTALS

FORMATION OF HYDROPHOBIC FLOCKS

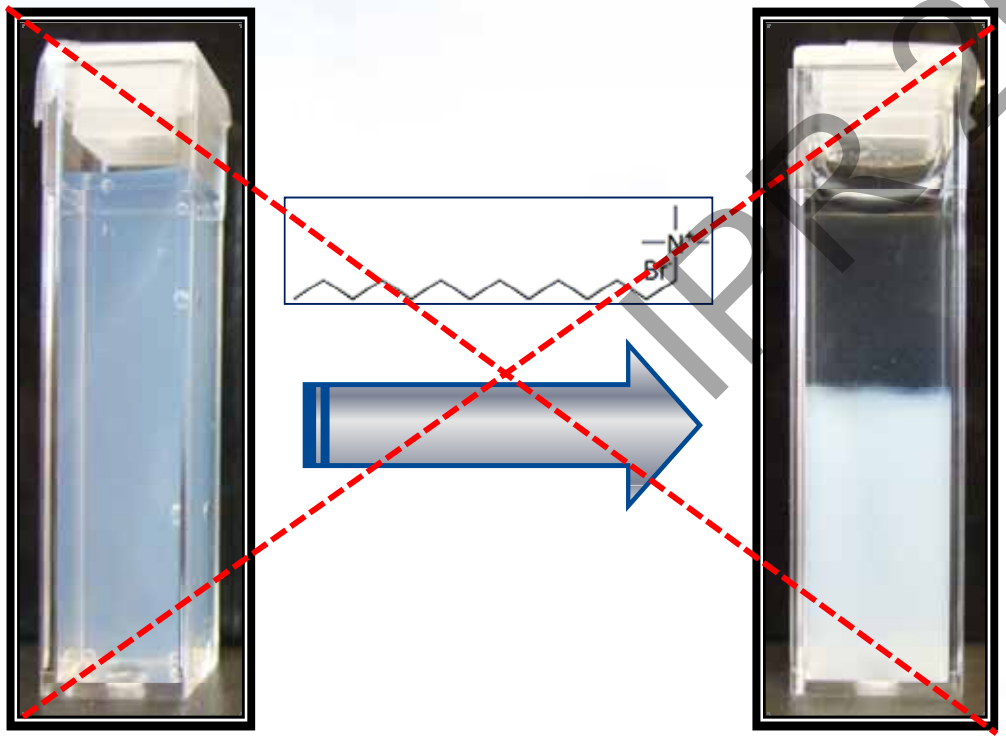




MEASUREMENT OF PHASE SEPARATION HEIGHT



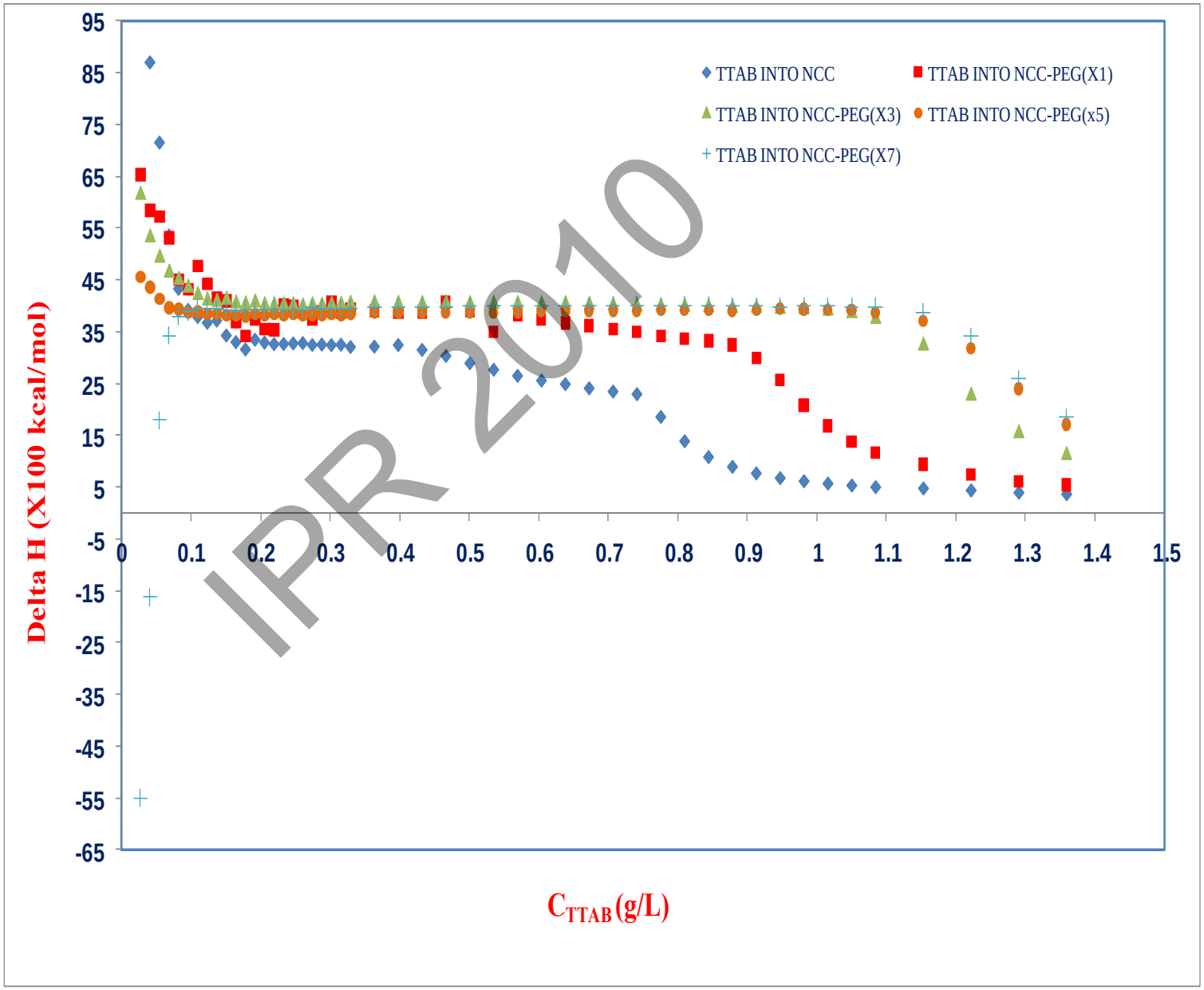
GRAFTING PEG ON NCC SURFACE



- **Steric stabilization of nanocrystalline cellulose by grafting PEG-2000, producing stable aqueous suspensions in presence of an oppositely charged surfactant**

- **Prevent formation of hydrophobic flocks & consequent phase separation**

ITC RESULTS FOR PEG GRAFTED NCC



FUTURE WORK

- Synthesis of robust polyampholyte microgels using modified PVA as crosslinker

- Incorporation of methylcellulose in the synthesized microgel particles
  - pH & temperature responsive properties

- Steric stabilization of nanocrystalline cellulose by grafting PEG-300
  - Prevent formation of hydrophobic flocks & consequent phase separation

SUMMARY

- Cellulose based Polyampholyte Microgels have been synthesized using inverse microemulsion polymerization

  - Microgels show swelling at high and low pH & deswelling at IEP

- Binding interactions of nanocrystalline cellulose with an oppositely charged surfactant has been studied using various techniques

  - Three kinds of polymer-surfactant interactions are observed:

Electrostatic binding, polymer induced micellization and hydrophobic interactions

THANK YOU