# Diapers and Superabsorbent Polymers Lab.



Ref: Bjerklie, D., Technology Review (May, June 1994) p. 44-45

## Absorbency vs Superabsorbency

- the difference between Absorbency and superAbsorbency is CHEMISTRY.

- Absorbency: Sponge soaking up water.
  - physical phenomena — $H_2O$ molecules temporarily trapped within the interstices of the sponges porous fibers.
    - Sponge can hold 10X its weight in liquid.
    - liquid easily released by squeezing.

### Superabsorbency

- chemical process — formation of hydrogels in the interstices of the "fishnet-like" lattice structure.
- Hydrogels form when $H_2O$ bonds to specific groups on the backbone of the macromolecule.
- 3-D fishnet structure forms when crosslinking agents connect the polymer molecules.
- Superabsorbent material: charged polymer + crosslinking agent.

$$\text{superabsorbency} = f(\text{conc}_{\text{polymer}}, M_w, [\text{conc x-linker}])$$

### Absorbency vs Strength (fundamental tradeoff)

- Loose mesh → several hundred times weight pick-up.
  → release $H_2O$ more easily (like sponge).
- Tight mesh → holds less $H_2O$ (~ 50-100X weight-pick-up)
  → stronger — retain more $H_2O$ under pressure.

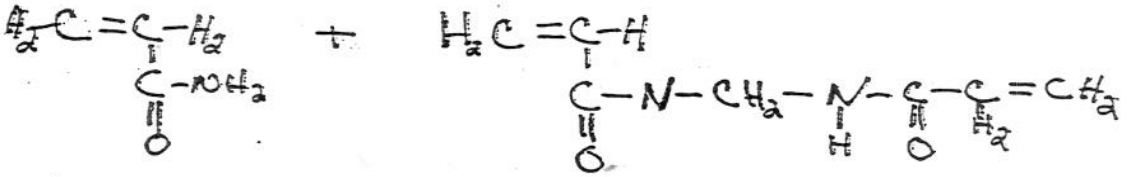
# Super Absorbant Polymers (SAP)



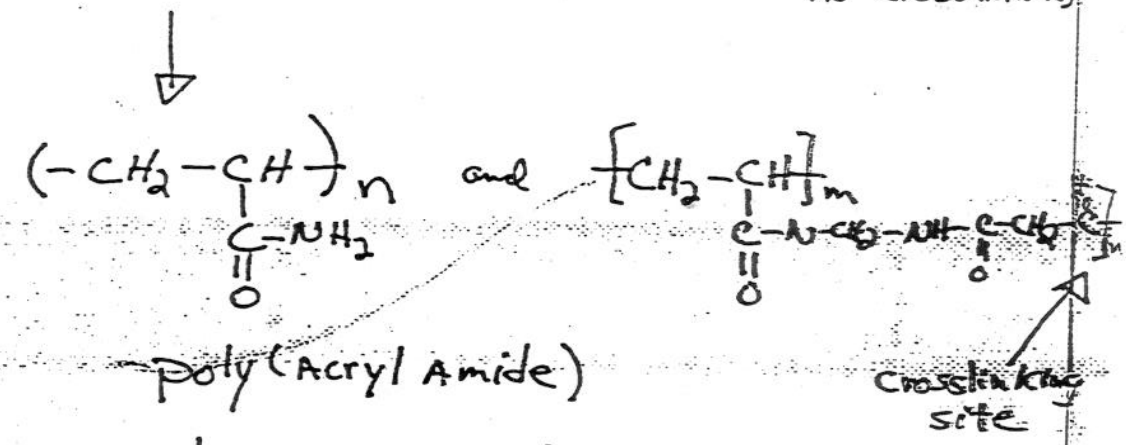
- Xerogellants (dried polymer gels that can be rehydrated to form hydrogels)
- almost all commercial SAP's are Anionic Polyelectrolyte
  i.e., negatively charged backbone or sidechain
- two major classes of commercial SAPs.
  1) Sodium Polyacrylates. (DOW)
  2) polyacrylic acid / starch (grafted) (Hoechst-Cela



Example: Sodium Polyacrylates.

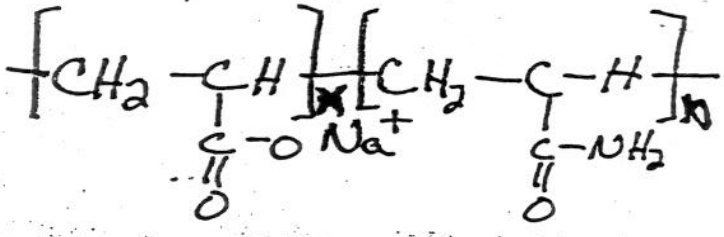


Acrylamide + bis(Acrylamide) (~ 1-2 wt% as crosslinker)




(0.01M NaOH)

hydrolyzes



Sodium polyacrylate (sodium polyacrylic acid)

where X = 30–50% of the units are hydrolyzed.

# Super Absorbant Polymers (SAP)

## Mechanism of Fluid Absorption

All SAPs are <u>XEROGELLANTS</u> "As received"

XERO Gellants: "dried gels" that can be swollen back to the "wet gel" state with fluid.



**Mechanism: Osmotic Pressure Driven.**

- The ability to absorb fluid is controlled by the <u>gel osmotic pressure</u>

LARGE and positive for good SAP

$$\Pi_{gel} = (\Pi_{\text{elastic network}}) + (\Pi_{\text{solvent-polymer interactions}}) + (\Pi_{\text{ionization}})$$

→ $\Pi_{\text{elastic network}}$ = elasticity of network formed.

- highly swollen gel – (-ve) effect on osmotic pressure

→ $\Pi_{\text{solvent-polymer interactions}}$ = polymer/solvent vs polymer/polymer affinity

- Attractive – polymer "likes" solvent – (-ve) effect on osmotic pressure (gel swells)
- repulsive – (-ve) effect on osmotic pressure

(Note: this (-ve) effect <u>diminishes</u> as solvent is imbibed and polymer/polymer interactions are less feasible).

→ $\Pi_{\text{ionization}}$ = hydrogen ion effect (or sodium ion effect)

- low ionic strength – anionic polymer repels itself expanding network and taking in fluid. (+ve) effect on osmotic pressure.
- high ionic strength (salt solution) – polymer network collapses due to charge screening

(-ve) effect on osmotic pressure