Thermal Polyaspartate as a Biodegradable Alternative to Polyacrylate and Other Currently Used Water Soluble Polymers

Scale Build Up in Industrial Water Handling Processes

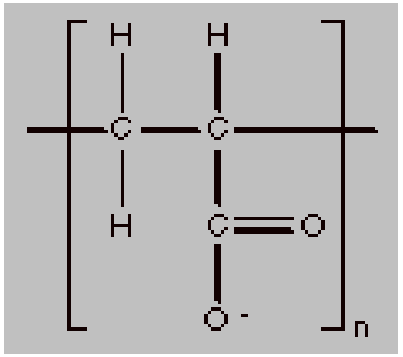
- Results in reduced water flow though pipes,
- Reduced heat transfer in boilers and condensers,
- Pump failures.
- Scale consists of insoluble inorganic compounds such as calcium carbonate, calcium sulfate, and barium sulfate.

Antiscalants

- Prevent scale formation entirely or
- Permit the scale to be deposited in such a way that it is easily removed by the fluid flowing along the pipe or heat transfer surface.
- Antiscalants complex with the cations present in water to prevent formation of the insoluble inorganic solids.

Polyacrylate

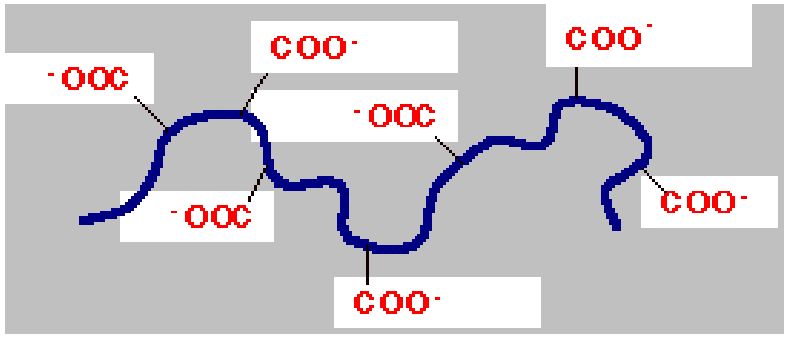
- **Polyacrylate (PAC) is one of the most common scale inhibitors.**
- **PAC is a polyanion.**



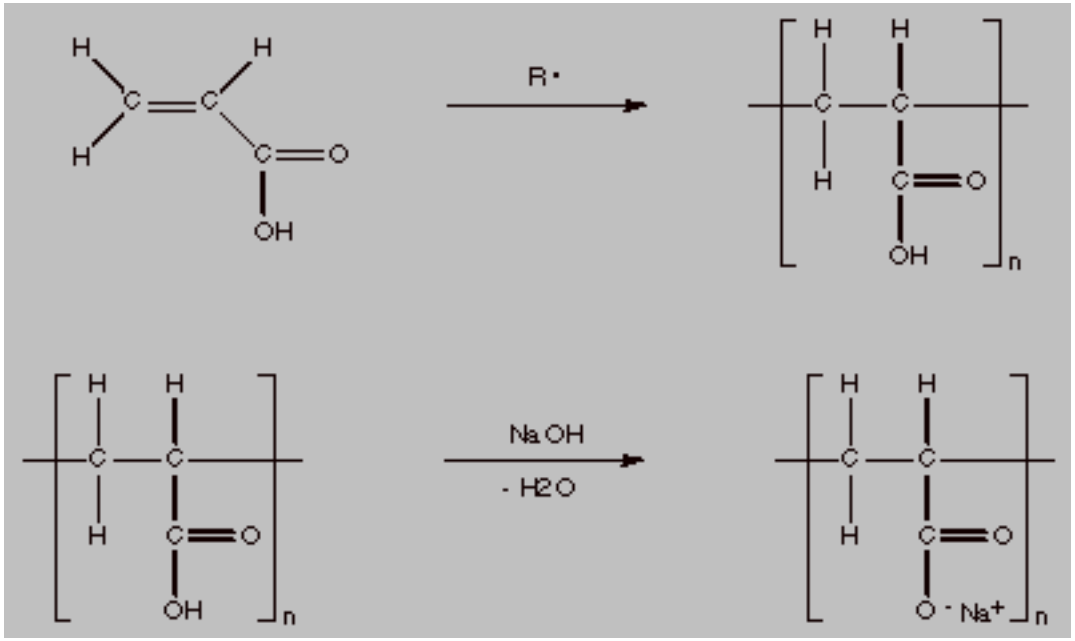
Polyelectrolytes

- Are polymers with bound positive or negative charges
- Are also called macroions or polyions
- Can be polyanions or polycations
- Are generally water soluble polymers if their structure is linear

Polyanions



Synthesis of Polyacrylic Acid and Conversion to Polyacrylate



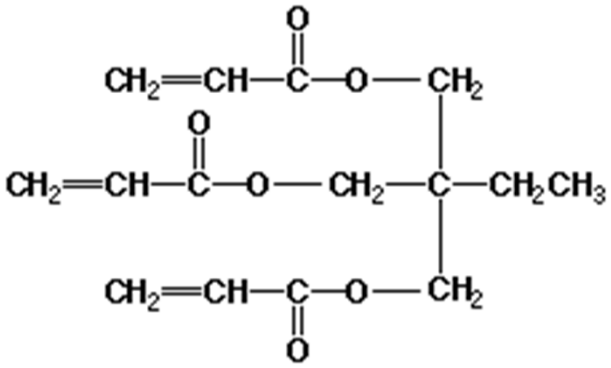
PAC as an Antiscalant or Dispersant

- Polymeric antiscalants are generally low molecular weight polymers.
- Polymeric dispersants consist of higher molecular weight fractions.
- Dispersants do not stop the formation of scale, but instead are able to keep the scale particles suspended in the bulk fluid by imparting a negative charge to the particles.
- PAC comprises 5% of many laundry detergent formulations because of its dispersant properties.

Crosslinked PAC

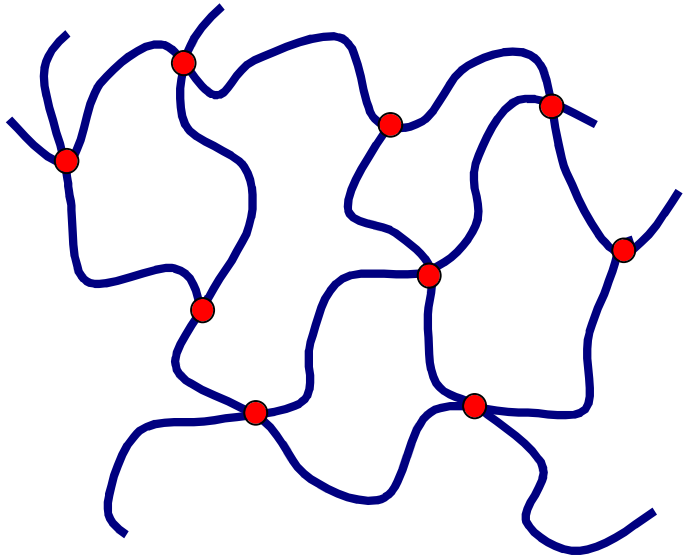
- A crosslinked form of the sodium salt of polyacrylic acid is used as a superabsorbant material in diapers and other personal hygiene products.
- Crosslinked PAC has a great affinity for water, but is unable to dissolve and will instead swell in aqueous solution.
- Because of the presence of the charged groups on the polymer chain of a polyelectrolyte, the polymer will be highly expanded in aqueous solution.

Crosslinking Agent



Comparison of Dry Crosslinked Polymer with Swollen Crosslinked Polymer

Dry Crosslinked Polymer



Swollen Crosslinked Polymer

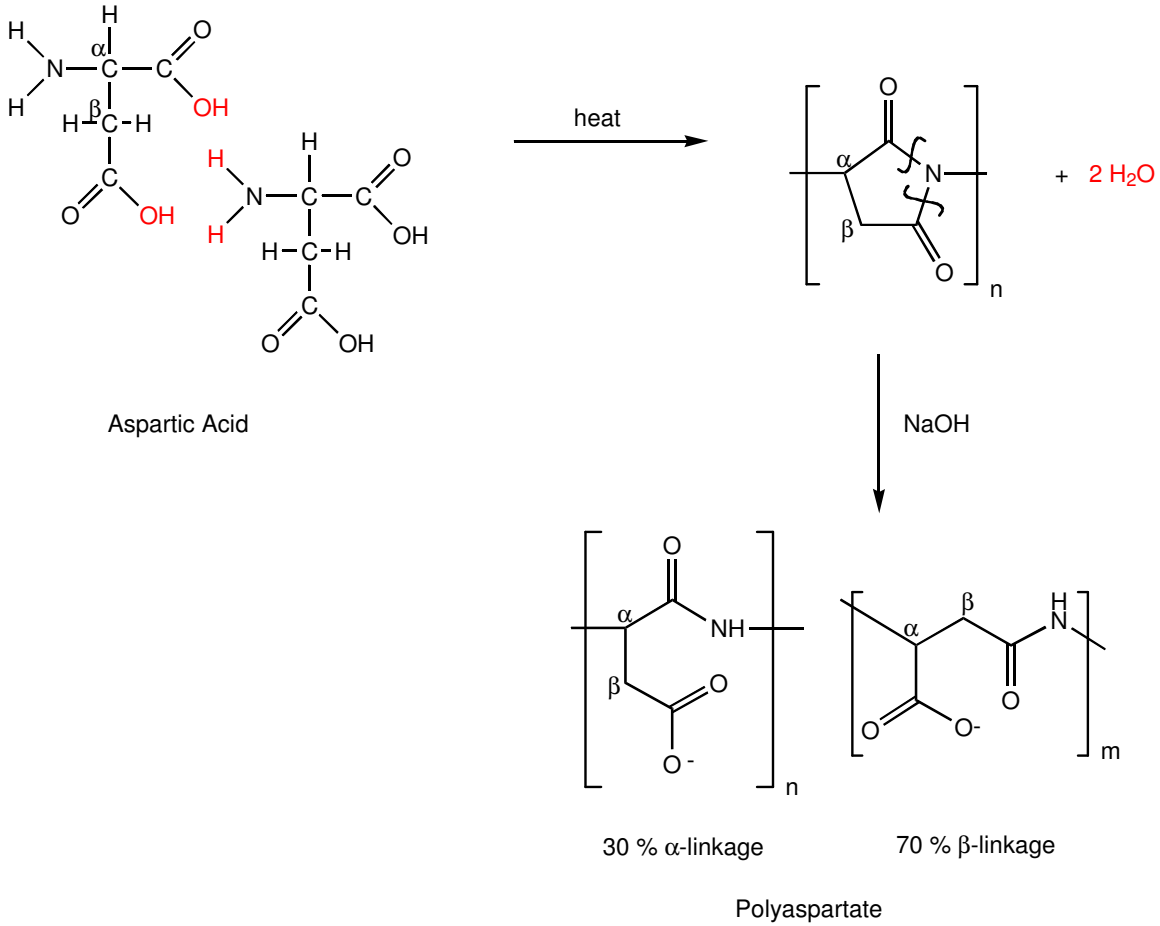
PAC and the Environment

- PAC is nontoxic and environmentally benign, but it is not biodegradable.
- Because it is widely used for many applications, it poses an environmental problem from a landfill perspective.
- When PAC is used as an antiscalant or a dispersant, it becomes part of wastewater.
- PAC is nonvolatile and not biodegradable, so the only way to remove it from the water is to precipitate it as an insoluble sludge.
- The sludge must then be landfilled.

Green Chemistry
Thermal Polyaspartate

- The Donlar Corporation developed an economic way to produce thermal polyaspartate (TPA) in high yield and with little or no waste products.
- Polyaspartate is a biopolymer synthesized from L-aspartic acid, a natural amino acid.
- Polyaspartate has similar properties to the polyacrylates and so it can be used as a dispersant, or an antiscalant, or a superabsorber.
- Polyaspartate is biodegradeable.

Synthesis of Thermal Polyaspartate



Aspartic Acid

Polyaspartate

Green Chemistry *in ACTION*

- In April 1997, Donlar opened the world's largest manufacturing facility for biodegradable polyaspartates, in Peru, Illinois.
- The opening of this facility resulted in commercial availability of TPA.
- TPA is marketed and sold as a corrosion and scale inhibitor, a dispersing agent, a waste water additive, a superabsorber, and also as an agricultural polymer.
- As an agricultural polymer, TPA is used to enhance fertilizer uptake by plants.
- Less fertilizer is added to the soil and the environmental impact from fertilizer run-off is reduced.

Donlar Corporation

- A small company founded in 1990 that is committed to producing environmentally friendlier products.
- The Donlar Corporation received the first Presidential Green Chemistry Challenge Award in the small business category in 1996.
- Donlar has received several U.S. and foreign patents for the manufacture, composition and end use of their bioenvironmental technology.