

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

Scale Build Up in Industrial Water Handling Processes

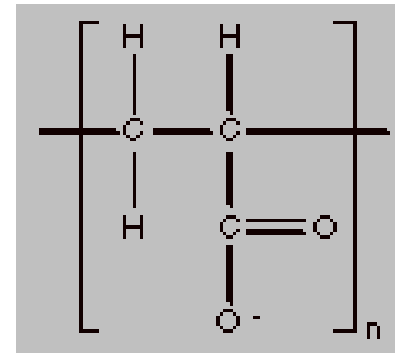
- **Results in reduced water flow through pipes,**
- **Reduced heat transfer in boilers and condensers,**
- **Pump failures.**
- **Scale consists of insoluble inorganic compounds such as calcium carbonate, calcium sulfate, and barium sulfate.**

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

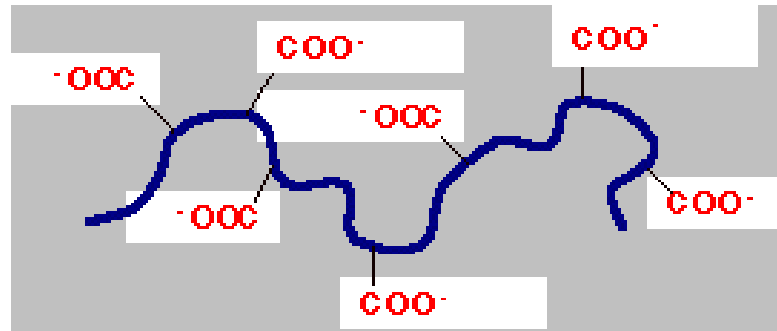
- **Polyacrylate (PAC)** is one of the most common scale inhibitors.
- **PAC is a polyanion.**



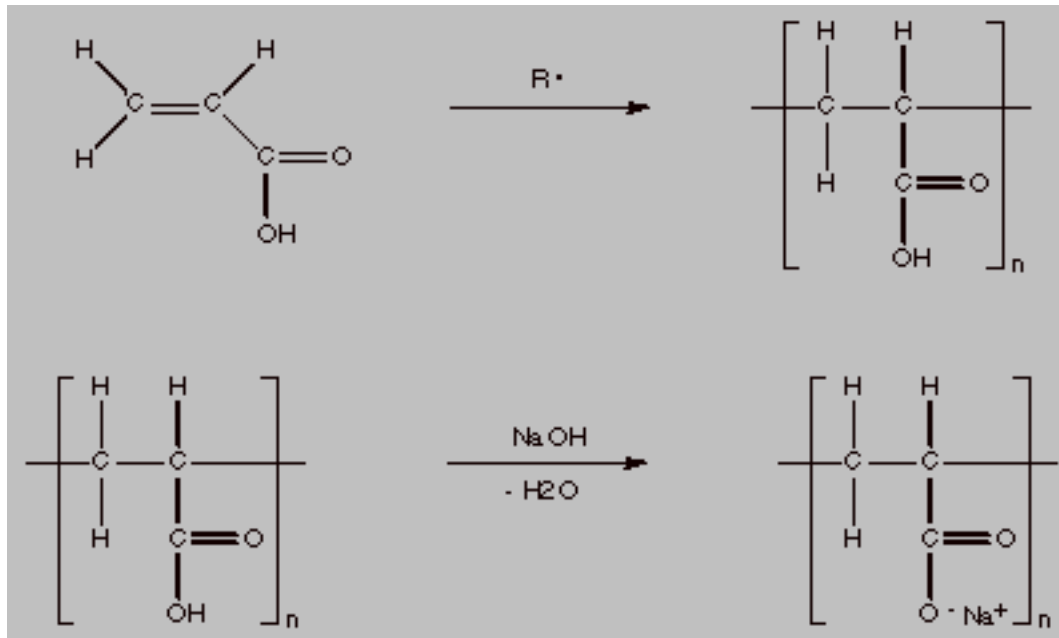
Polyelectrolytes

- **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



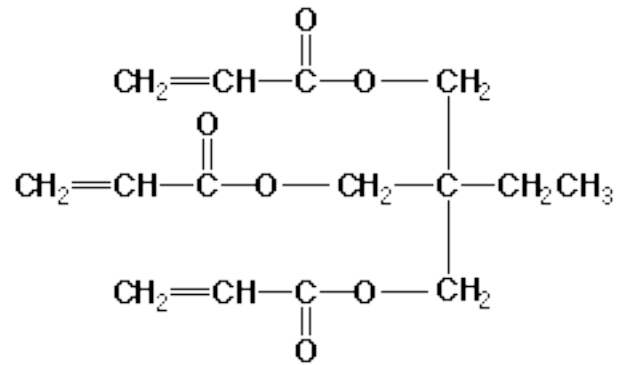
PAC as an Antiscalant or Dispersant

- **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.**

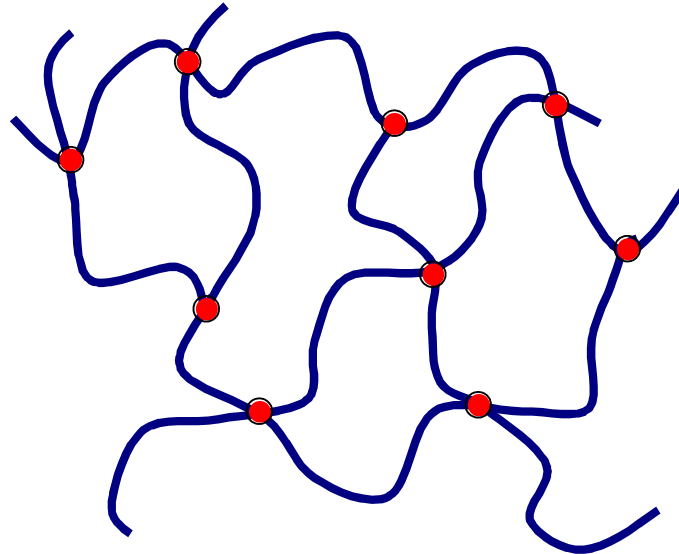
Crosslinking Agent



Comparison of Dry Crosslinked Polymer with Swollen Crosslinked Polymer



Dry Crosslinked Polymer



Swollen Crosslinked Polymer

PAC and the Environment

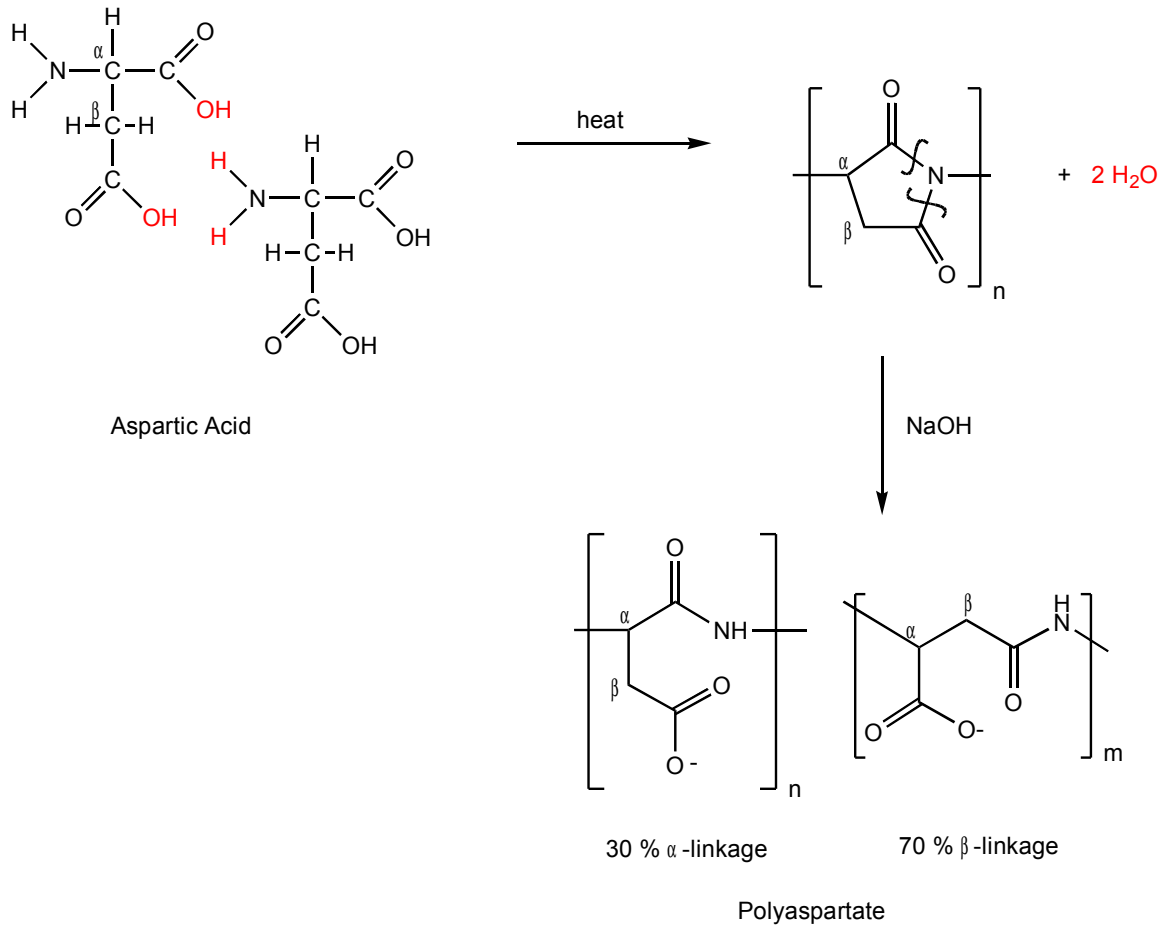
- **PAC is nontoxic and environmentally benign, but it is not biodegradable.**
- **Because it is widely used for many applications, it poses an environmental problem from a landfill perspective.**
- **When PAC is used as an antiscalant or a dispersant, it becomes part of wastewater.**
- **PAC is nonvolatile 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



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.**