

# **Radiation Effects on Polymeric Systems**

## **Polyethylene Crosslinking**

**Wire and Cable Insulation**

**Heat-Shrink Products**

# **Plastics Used in Wire and Cable Insulation**

**PVC**

**PE and copolymers**

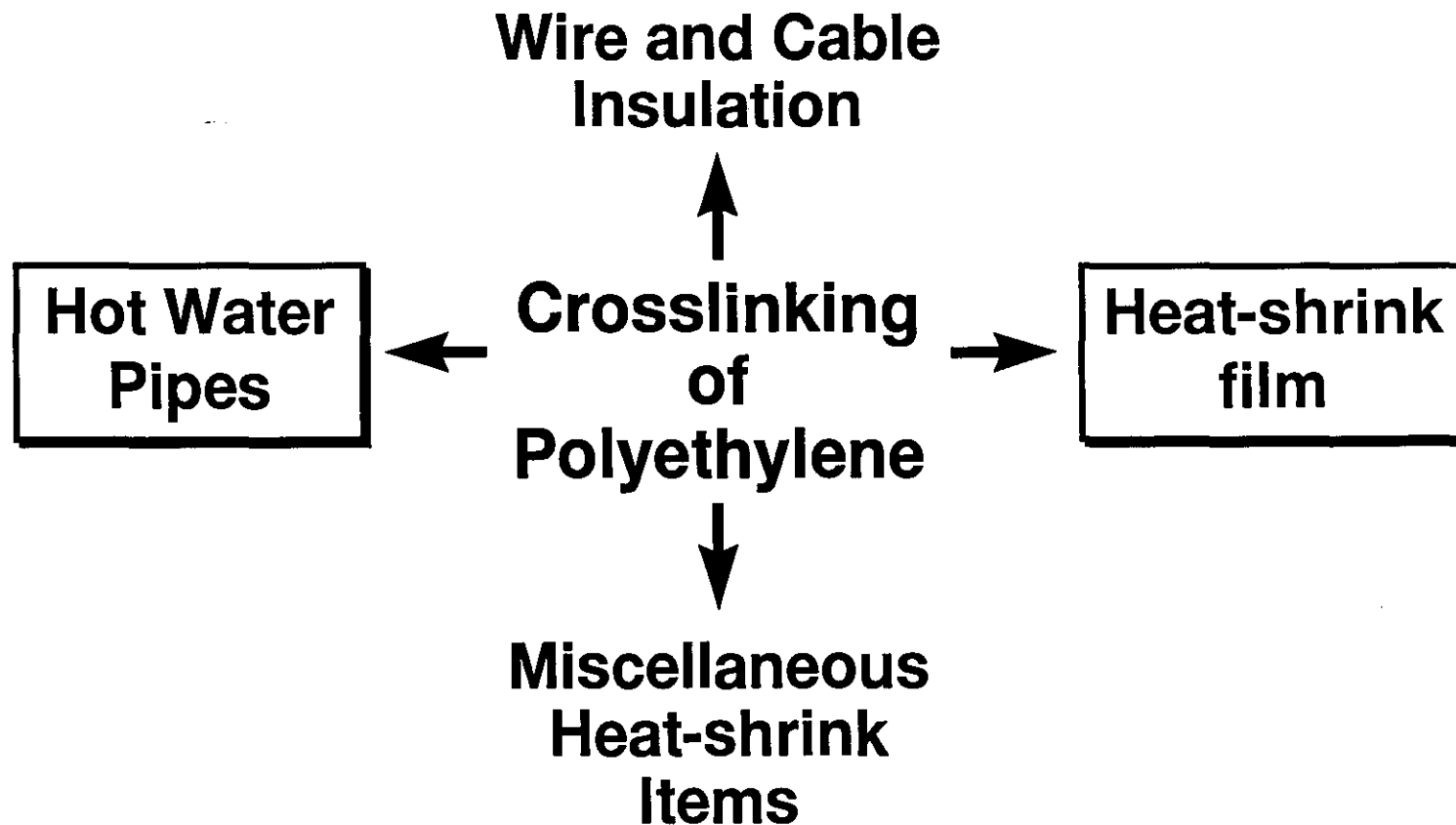
**EPDM**

**Chlorosulfonated PE**

**PE/EVA Copolymer**

**Fluoropolymers**

# **Crosslinking of Polyethylene is of Great Industrial Interest**



# **Heat-Shrink Products**

- **Based on crosslinking of polyethylene and other polymers (PVC, PVDF, rubbers, acrylates, etc.)**
- **Include films, sheets, tapes, tubes and shaped products**
- **Basis of the technology, the “memory effect” (cross-linking in the amorphous regions and “none” in the crystalline regions)**
- **Heat-shrink products a uniqueness of radiation treatment; not possible with thermal/peroxide process**
- **Electric connectors and poultry packaging two prominent examples**

# **Crosslinking of Polyethylene**

## **Advantages**

- **Increased tensile strength**
- **Higher service temperature**
- **Improved weathering characteristics**
- **Increased resistance to stress cracking**
- **Decreased solubility**

## Radiation and Chemical Crosslinking of PE as Wire and Cable Insulator

Parameter	Irradiation	Chemical (Peroxide)
Temperature	ambient (<70°C)	high (~125°C)
Atmosphere	air (electron or nitrogen)	air
Crystallinity	hardly affected	lost
Crosslinking	amorphous regions	uniform
Dimensions of insulation	unchanged	some non-uniformity
Post-treatment annealing	desirable (70-85°C, ~1h)	not needed
Dielectric properties	better	initiators harmful
Cost	lower	higher
Production speed	higher	lower
Quality	better	poorer
Environmental effects	better	poorer

Silverman (1992)

# **Factors that Affect Radiation Crosslinking of PE**

- **Presence of oxygen**
- **Presence of additives**  
(anti-oxidants  
fire retardants  
crosslinking agents)

# **Crosslinking in Crystalline Regions of PE**

## **A Controversial Topic**

- **Patel and Keller (1975) prepared crystalline monolayers of PE**
  - **Concluded that there is no crosslinking in the crystalline regions on irradiation**
- **Tabata and coworkers (1984, 1991) have concluded that there is some crosslinking (~1/3rd) in the crystalline regions**



# **Aim of 10 MeV Electron Irradiation of Polyethylene**

**Determine whether commercial samples of PE  
can be crosslinked with 10 MeV electrons, on  
irradiation in air, to a gel fraction greater than 70%**

## **Result**

**Commercial polyethylenes can be crosslinked in  
air by 10 MeV electron irradiation to yield the gel  
fraction required (70%) for wire and cable  
insulation**

## **Conclusions**

- **Radiation crosslinking for the production of heat shrink products would continue to grow**
- **Since radiation crosslinked PE has better insulator properties, this would also remain a growth area**
- **Radiation processing has enabled the plastics industry to expand the scope of their markets**
- **Continuing R&D should further expand the use of radiation processing in the plastics industry**