Radiation Effects on Polymeric Systems

Polyethylene Crosslinking

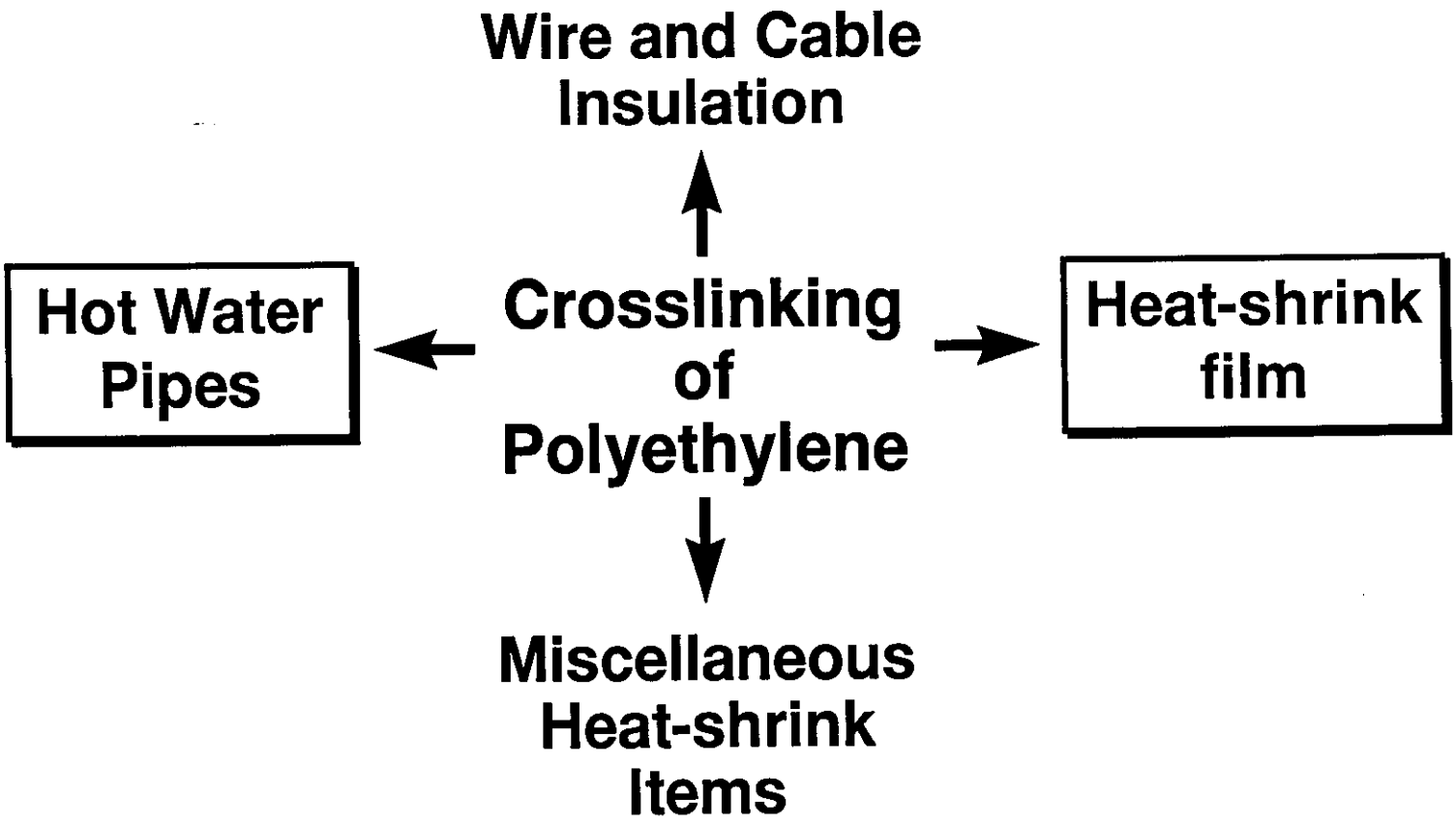
Wire and Cable Insulation

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 Controvercial 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 irradation 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