

Chapter 7

Trends in Applications



□ packaging materials

- polymer 40+%, paper 30%, metal 20%, glass 10-%
- polymer portion increasing
 - environmental and recycle concern increase

□ polymers used

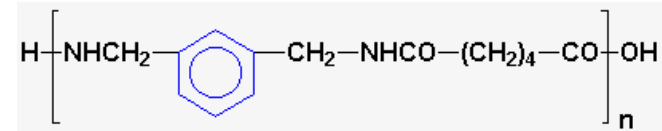
- PE
 - LD ~ branched, easy processing, clear film
 - LLD ~ linear, higher strength, stretch-cling film
 - VLD ~ lower X_c , low-temp strength, high permeability
 - HD ~ high X_c , high strength, higher barrier

- PP
 - stiffer, higher (tensile, tear) strength
 - higher (moisture) barrier, printable
 - versatile and inroading others (PVC, PS, even PET) fast
 - (B)OPP ~ (biaxially) oriented
 - higher strength, clear, glossy, food (snack)
 - random PP
 - lower X_c , transparent, high IS
 - low temp food container
 - HCPP
 - high X_c , stiffer, harder, better high temp property

- PET
 - high strength, high barrier
 - PEN ~ higher gas barrier, strength, heat and chem resistance
- nylon ~ high strength, high barrier
- PS ~ clear, merchandise packaging, brittle, diminishing
- PVC ~ plasticized, versatile (film to bottle), diminishing

- food packaging
 - usually multilayer
 - extrusion coating, coextrusion, laminating
 - PO ~ structural layer
 - EVOH, PVDC ~ gas barrier
 - PP ~ printable
 - PE, ionomer ~ heat-sealing
 - retort ~ ready-to-cook, pasteurize with pressure/heat
 - PP/EVOH, PVDC, Al for barrier/PP, PC, PET (outside)
 - aseptic packaging ~ Tetra Pak ~ milk, juice
 - PE/EVOH/paper/PP (outside)
 - hot-filling ~ bottle, pouch ~ juice, ketchup
 - LLD/EAA/Al/EAA/nylon

- controlled (or modified) atmosphere film
 - barrier ~ high CO₂/no O₂ ~ PVDC, EVOH ~ meat
 - selectively permeable ~ CO₂ out/air barrier ~ HDPE/PET ~ vegetable
 - oxygen-scavenging layer ~ polymer with oxidizable group like cyclohexene
- ovenable
 - dual ~ high X_c PET, PC, unsat'd polyester, PEI
 - microwave only ~ PP
- high-barrier layer
 - nylon ~ MXD6 ~ aliphatic-aromatic polyamide
 - PET modified with silica, alumina, LCP
 - Saran ~ P(VC-VDC)
 - nanocomposites



□ bottles

- general ~ LD and HD
- soda ~ PET
- beer ~ oxygen barrier ~ PET/nylon (or PVDC)/PET
- oil ~ (B)OPVC

□ chemical containers

- general ~ HDPE
- solvents ~ high barrier
 - fluorination
 - nylon, PVDC, EVOH layer

Building and construction

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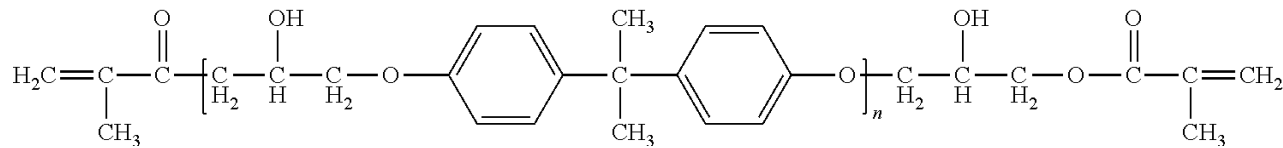
- polymer replacing wood, cement, metals
 - cost, appearance, durable
- roofing
 - thermal insulation; elastomers (EPDM, PE) replacing bitumen
- flooring
 - general ~ PVC, filled PVC, PP
 - seamless ~ pourable epoxy, PU
- windows
 - frames ~ PVC with acrylates, CPE, EVAc
 - self-frosting ~ PDLC
 - Optica film ~ alumina deposited PET
- pipes
 - corrosion resistant, easy handling
 - PVC, HDPE, CPVC, ---

- insulation
 - foamed PU, PS, UF
- polymer-concrete composite
 - large increase in durability, barrier, strength
 - PIC (polymer-impregnated concrete) ~ precast; monomer + cement (+ crosslinker); acrylates
 - PCC (polymer-cement concrete) ~ cast in place; latex of SBR, NBR, acrylates
 - PC (polymer concrete) ~ no cement; flooring; epoxy, unsat'd polyester, acrylates
- WPC (wood-plastic composite)
 - window frame, door, deck
 - stiffer and higher dimensional stability than polymer only

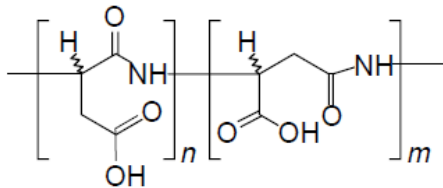
Corrosion control

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- polymers ~ high corrosion-resistant, low heat-resistance
- flue gas desulfurization system ~ acid, high temp
 - epoxy, fluoropolymer, vinyl ester



- chemical resistant masonry ~ chemicals, high temp
 - fluoropolymer, epoxy
- pipe-cleaning ~ ultra-high MW PAAm
- scale inhibitor ~ boiler and cooling water; PAA, PAA-SA, polyaspartates (biodegradable) ~ corrosion, viscosity



□ trend

- weight reduction ~ size, material, design
- ecology ~ recycling, thermoset ↓, PO ↑
- economical ~ consolidation, module
- sensibility

□ exterior

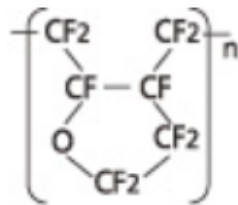
- body [panel and trim] ~ high E, IS, HDT, paintability
 - PU, Noryl GTX [nylon/PPO], Elemid [nylon/ABS]
- bumper ~ high IS, paintability
 - PU, Xenoy [PC/PBT], PP, TPO
- fuel tank ~ high strength, barrier, chemical resistance
 - HDPE (high MW)

cf> filled or unfilled, nanocomposite

- 현대차 제네시스 시트, 가죽 버리고 플라스틱 쓴다 [2019.12.03]
- 현대자동차 제네시스 모델에 쓰이는 좌석용 시트 소재로 가죽을 버리고 재활용이 가능한 고기능성 플라스틱을 선택한 것으로 알려지면서 업계에 적잖은 파장을 불러일으키고 있다. 최고급 자동차 전용 브랜드인 제네시스 내장재이기 때문이다.
- 고기능성 플라스틱인 '열가소성 폴리에스테르엘라스토머(TPEE)'를 사용키로 했다.
- 가죽은 소를 키워 도살한 뒤 가죽을 벗겨내고, 다시 대량의 화학 약품을 써서 가공해야 한다. 또 가죽 원단을 재단해 자동차 내장재를 만드는 데 버려지는 부분도 많이 발생한다. 하지만 고기능성 플라스틱은 환경 문제에서 시비가 덜하고, 재활용이 가능하다.
- 앞서 현대차는 미국 유명 디자이너 마리아 코르네호와 협업해 시트를 만들고 남은 자투리 가죽으로 옷을 만들어 미국 뉴욕 패션 위크에 참석하는 이색적인 '업사이클링(단순 재활용이 아니라 새로운 가치를 창출하는 것)' 이벤트를 선보이기도 했다.

- interior
 - ABS ↓, PP & TPO ↑
 - wood/polymer
 - PLA blend
 - biocomposite, green composite
 - natural fiber like hemp, cellulose
 - synthetic or natural polymer
- under-the-hood ~ high E, TS, HDT
 - engineering plastics ~ PA, PEEK, PES, PI, PTFE
- aerospace ~ moderate to high HDT
 - fiber ~ carbon, aramid
 - resin ~ epoxy, PI, engineering plastics

- cable insulation
 - general ~ PE, XLPE, EVAc, PVC, PP
 - high resistant ~ fluoropolymers, PI, PEEK, silicone
- PCB
 - glass-filled epoxy
 - injection moldable ~ PET, PES, PEI, PSF
- connectors ~ high temp ~ PPS, PET, PEEK
- optical fiber
 - sheathing GOF ~ nylon, fluoropolymers, POM, PBT
 - POF ~ PMMA/fluoropolymer → CYTOP (low loss)
- discs
 - hard disc ~ PEI, PET: CD ~ low MW PC



- film ~ greenhouse, covering soil
 - PE with UV stabilizer
 - special grades ~ heat-retaining, antistatic, degradable
- reusable crate ~ hinge ~ PP
- pipe ~ PVC
- hose ~ PE, XLPE

- Table 7.2
- refrigerator
 - insulation ~ PU foam
 - lining, --- ~ PS, HIPS, ABS, SAN, PC
- housings ~ ABS, PPO, Noryl, PP, PC
- parts ~ nylon, POM
- HEPA filter ~ PP fiber

- **Table 7.3**
- packaging ~ PE, PP, PET, CTFE (moisture)
- sterilizable items
 - steam, EO, gamma radiation
 - PVC ~ versatile (catheter, bag, tube) ~ plasticizer
 - PO ~ replacing PVC ~ gamma radiation weak
- implants ~ biocompatibility
 - silicone, PP, PU, UHMWPE (cartilage), PTFE (vessel)
- dental resin
 - PMMA, GMA, fiber reinforced
- biomimetic actuator ~ electroactive
 - ionic polymers, conducting polymers

Marine

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- umbilicals ~ density, kink-resistance ~ braided PU
- coatings ~ corrosion ~ PU, epoxy

□ surface

- track ~ PU
- synthetic turf ~ PP
- ice ~ HDPE
- indoor ~ PVC, PP

□ equipments

- shoe sole ~ PU and other elastomers
- Microsphere[®] by 3M ~ density control
- rackets ~ CF/nylon
- helmet ~ PC, ABS, nylon