IFATCC 2010, Stresa, Italy

Application of Electron Beam Irradiation Technique for Special Modification of Textile

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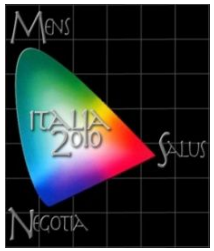


Textile Modification

- Coating, Laminating
- UV, Laser Irradiation
- Electron Beam Irradiation
- Plasma Treatment
- Spattering
- Ink Jet Printing
- Supercritical Fluid Technique
- Sol-Gel Method
- others

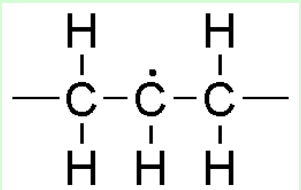
Radiation methods

γ Ray : Co^{60}

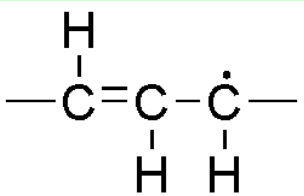
Electron beam : Electron flow with constant rate and direction

What will be happen on polymer materials by radiation?

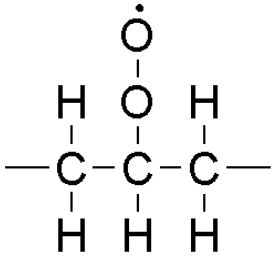
active radicals are formed



alkyl radical



allyl radical



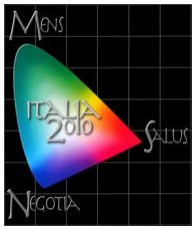
Peroxy radical

Radicals can react with any compounds.

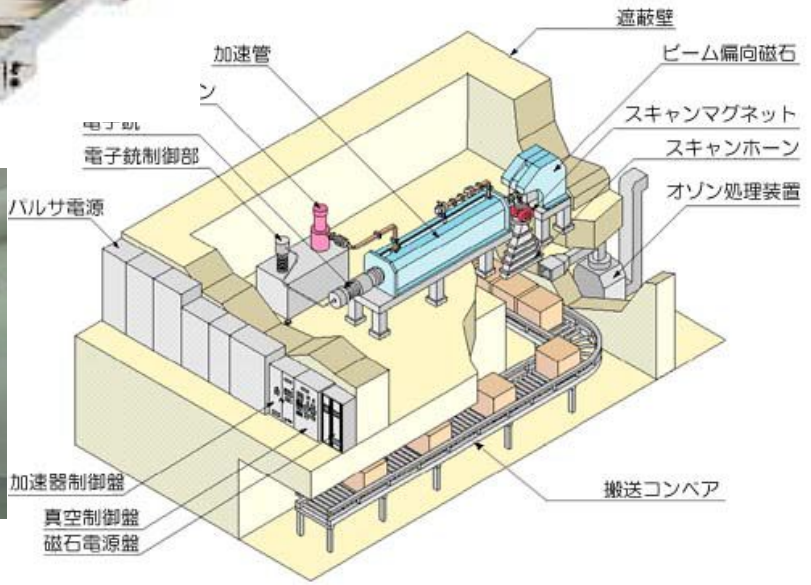
G-value of some polymer materials

(A measure of radical formation by radiation)

polymer	G Value
polyethylene	2.9~4.5, 6~8
polypropylene	3.3, 6.6
polystyrene	1.5~3
polyisoprene	2~4
poly(methyl methacrylate)	6~12
poly(vinyl acetate)	6~12
poly(vinyl alcohol)	~10
poly(vinyl chloride)	1.7~2.1, 10~15
poly(ethylene terephthalate)	0.023, 0.025
polyamide	0.1~1.1
cellulose	~10
wool	0.8



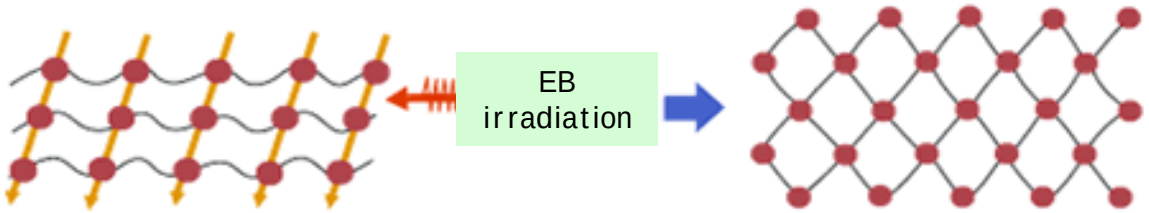
Various types of Plants



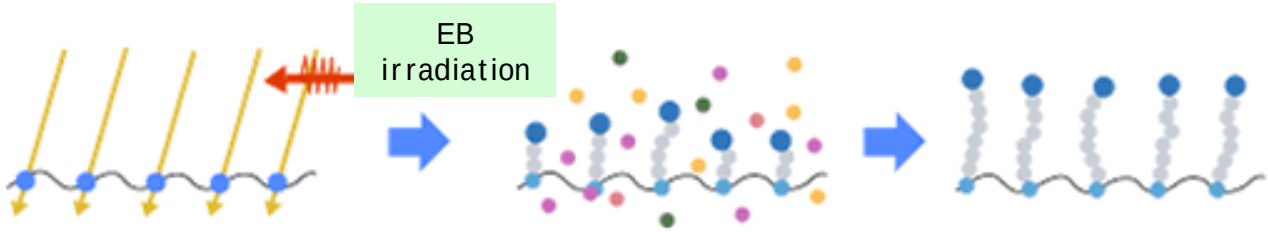
http://www.nhv.jp/index.html
http://www.iwasaki.co.jp/index.html
http://www.ushio.co.jp/index.html

Application of Radiation Technique

- Cross-linking



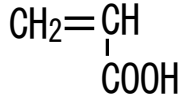
- Polymerization and Grafting



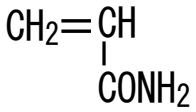
- Decomposition

disposal / waste treatments
powder making
etc.

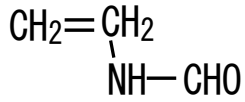
Some monomers for graft-polymerization



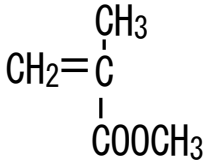
Acrylic acid (AA)



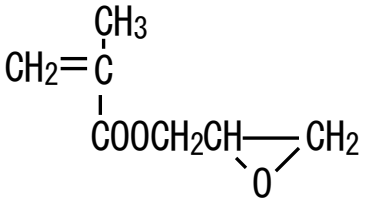
Acrylamide (AAm)



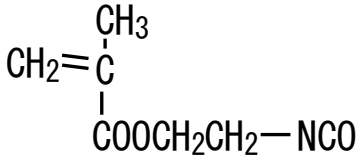
N-Vinyl Formamide(NVF)



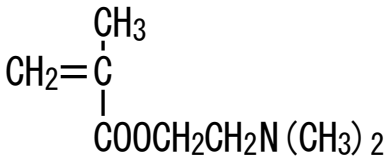
Methyl Methacrylate (MMA)



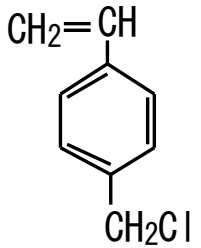
Glycidyl Methacrylate (GMA)



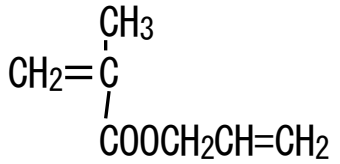
Isocyanate Methacrylate



Dimethylaminoethyl Methacrylate



Chloromethyl styrene (ClSt)



Allyl Methacrylate

others

Electron Beam Grafting for Textile Modification

Surface modification
(no changes in physical property)

Water-wettable / water repellent
Adhesive properties
Biocompatibility
Electric property

Bulk modification
(with changes in physical property)

Thermal property
Special function
Absorption property
Moisture/water absorbability

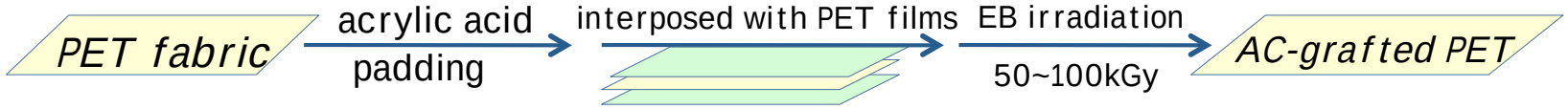
Application of EB irradiation to textile modification

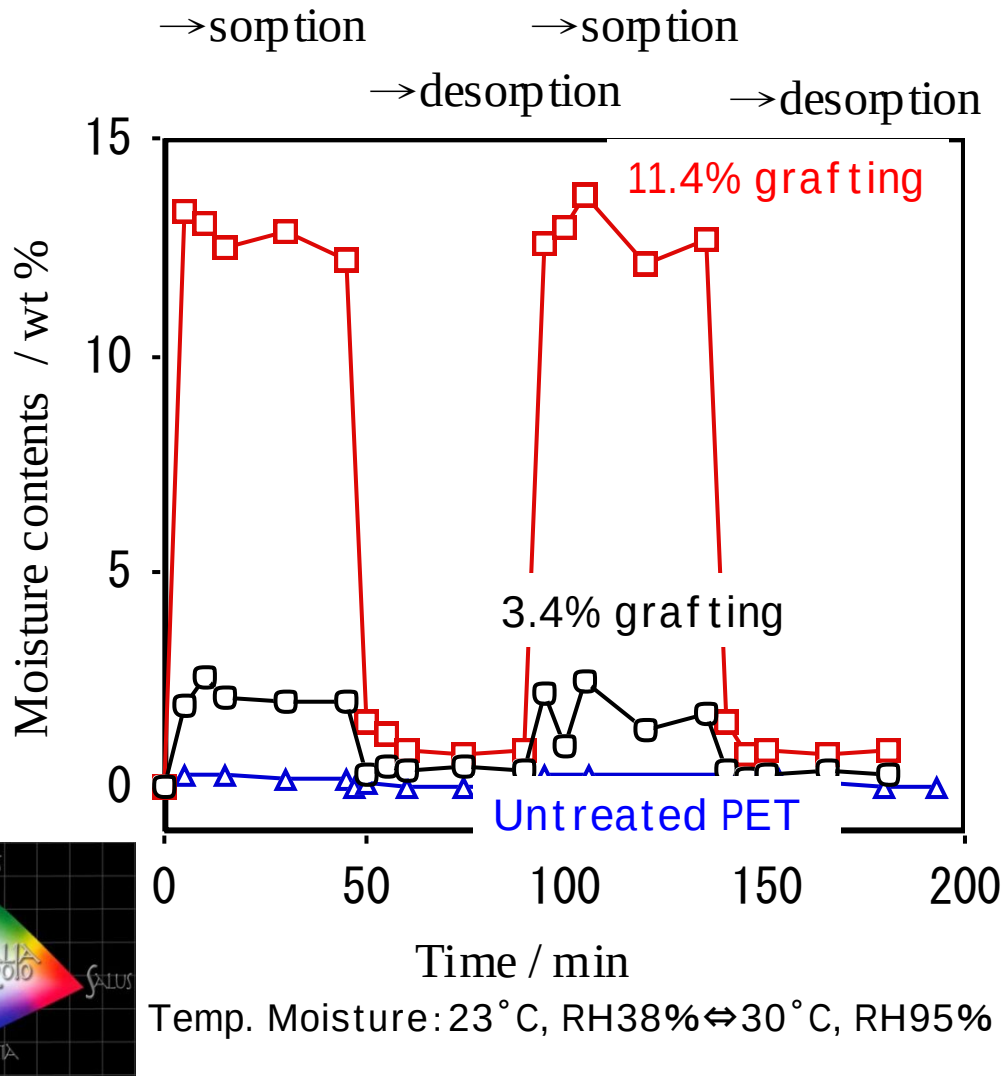
- To give functions
  - Water-wettable/water repellent property
  - Adhesive property
  - Anti-bacteria function
  - Flame-resistant property
  - Biocompatibility
  - Electric property
  - etc.
- To make continuous EB grafting machine for textile materials

Laboratory EB machine

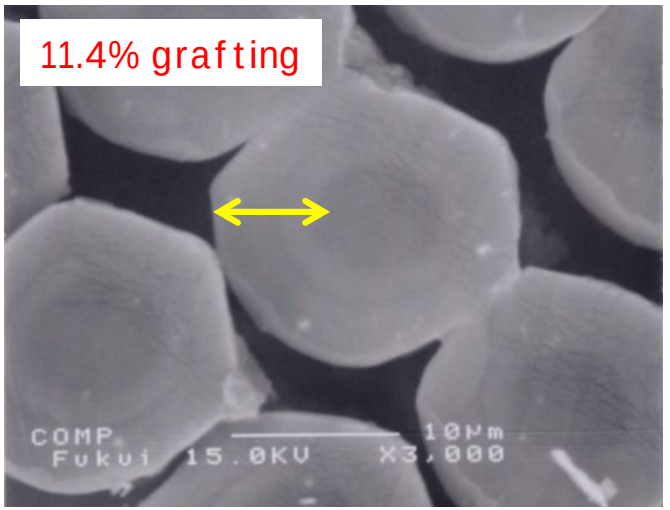
Specification	Iwasaki electronicsEC250/15/180L
High voltage	150～250 kV
Max Dose	1800kGy・m/min
Irradiated size	W150×L200×H25
Atmosphere	N_2 gas or Air

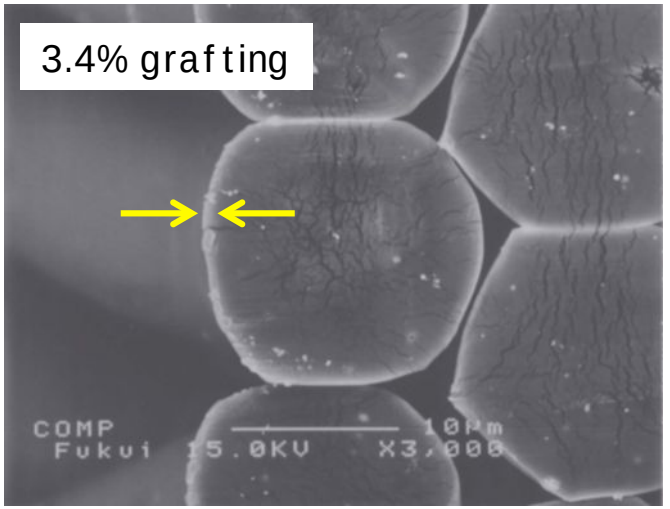
Grafting of acrylic acid on PET fabrics – water absorbable PET





Temp. Moisture: 23˚C, RH38%⇔30˚C, RH95%

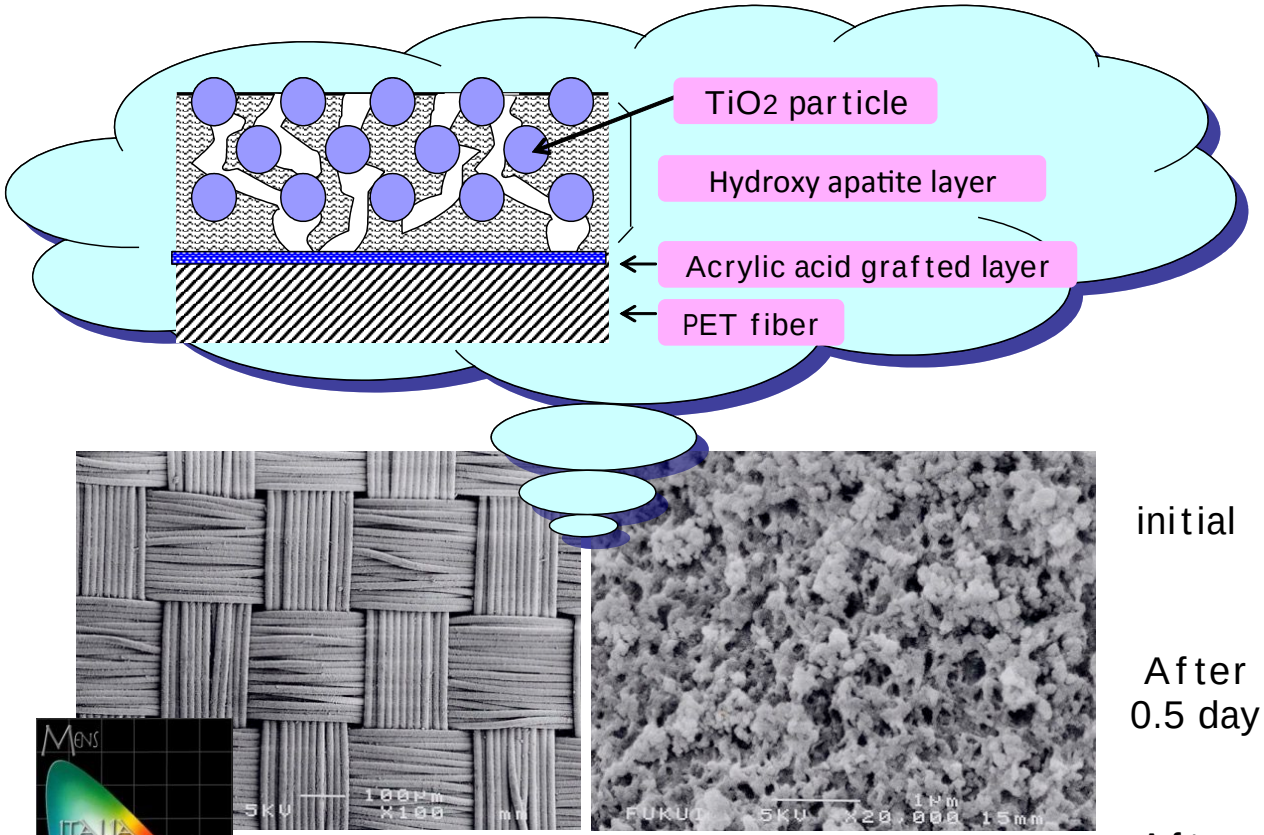




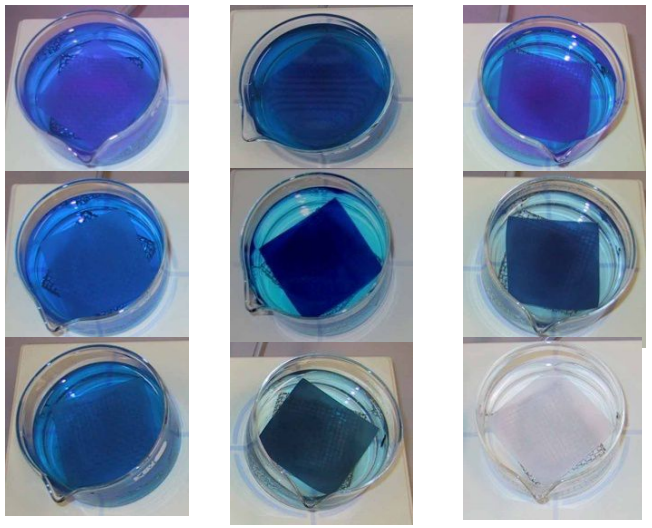
Hydroxy apatite/TiO2 formation on acrylic acid - grafted PET fabric

AC grafted PET

1) $CaCl_2$ aq. Soln.
2) H_2PO_4 aq.soln.
3) TiO_2 dispersion



Exp. : Decomposition of dye

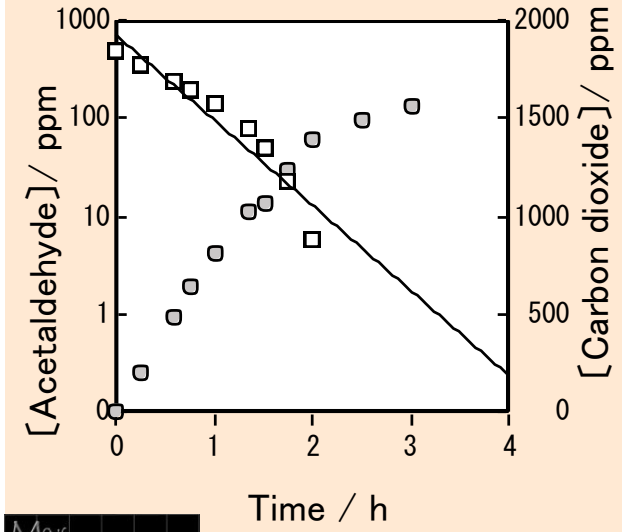


Decomposition of toxic compounds by apatite/TiO_2 treated fabric

Acetaldehyde

TiO_2 2.1 %, Apatite 6.8 %

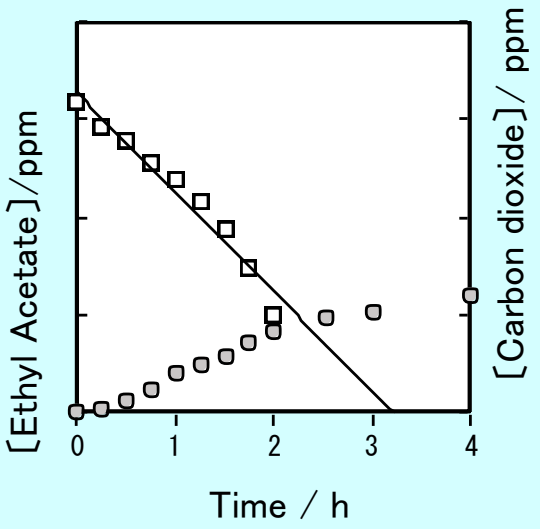
□: Acetaldehyde , ○ : CO_2



Ethyl Acetate

TiO_2 2.2 %, Apatite 6.9 %

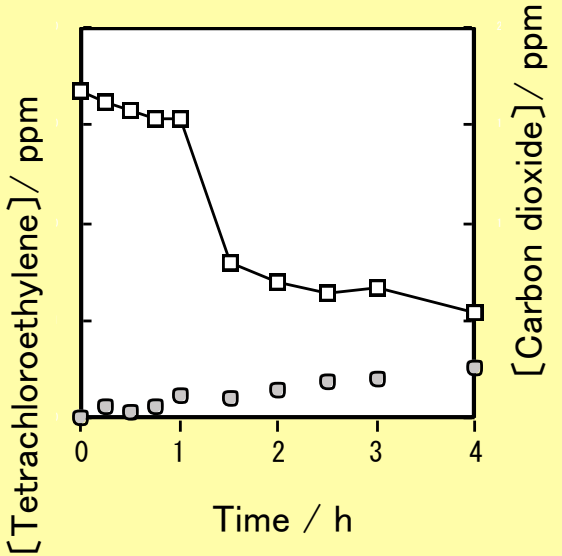
□ : Ethyl Acetate , ○ : CO_2



Tetrachloroethylene

TiO_2 2.2 %, Apatite 6.9 %

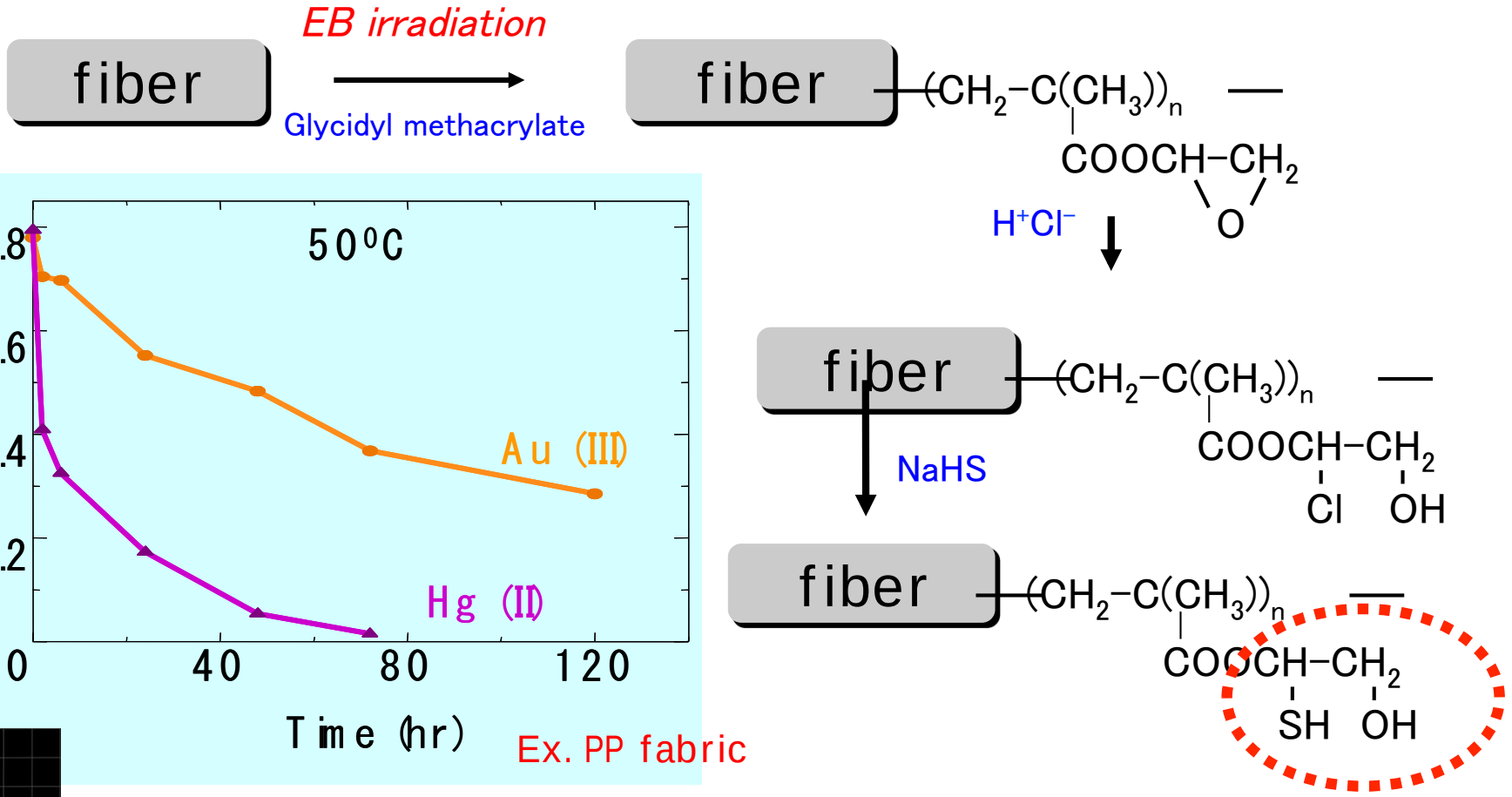
□: Tetrachloroethylene ○ : CO_2



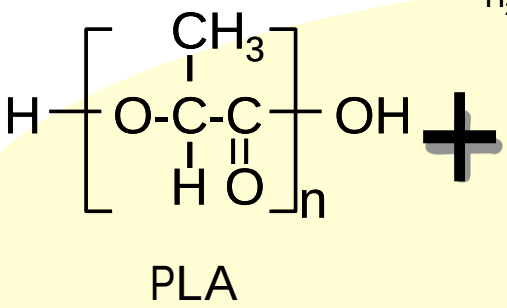
Cl^- recovery : 55%

Metal ion absorbable fiber

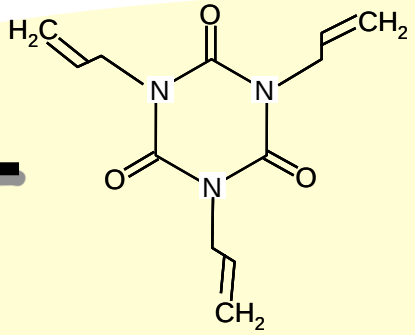
Suitable fibers : cellulosic, polypropylene, PVA etc



Heat-resistant PLA fabric



PLA



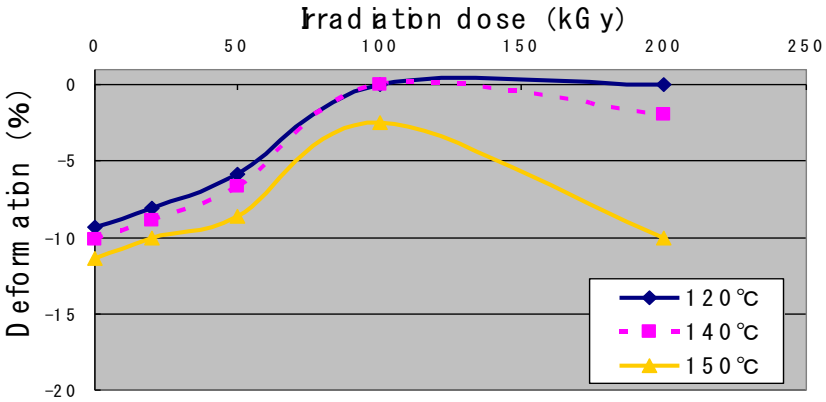
TAIC
Cross-linking agent

EB irradiation
200~400 kGy

not dissolved in solvents

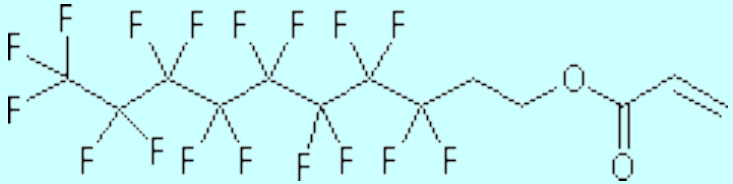
Iron test of treated PLA non-woven fabric

Shrinkage of treated PLA



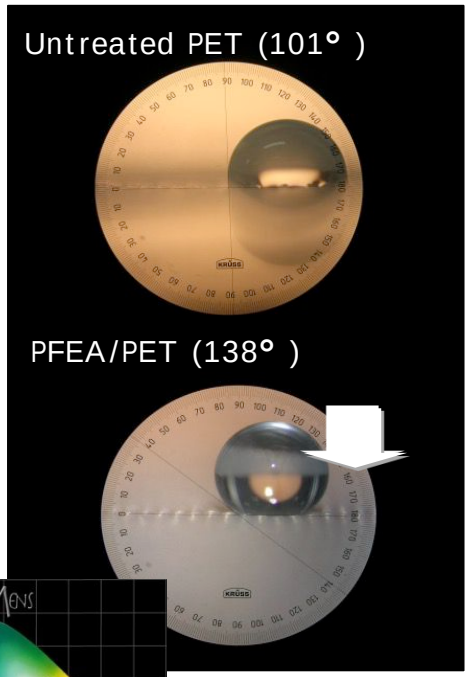
Water repellent PET fabric

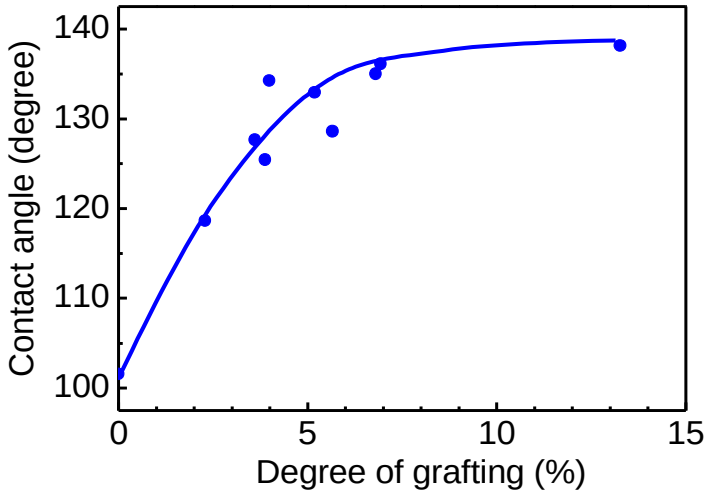
Vinyl monomer with fluorocarbon or silicon

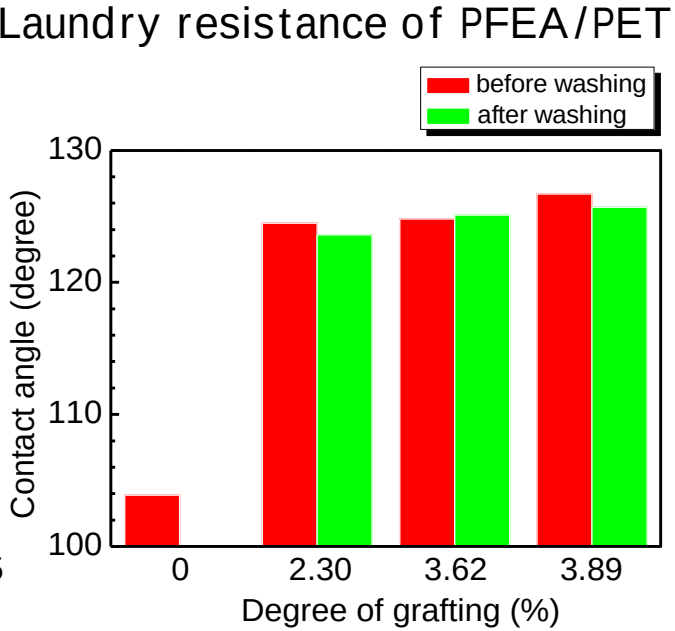


2-(perfluorooctyl)ethyl Acrylate
(PFEA: 522g/mol)

Vinyl silicon monomer
TX17-19A
(MW=*ca*. 1000g/mol)
TX17-19B
(MW=*ca*. 5000g/mol)

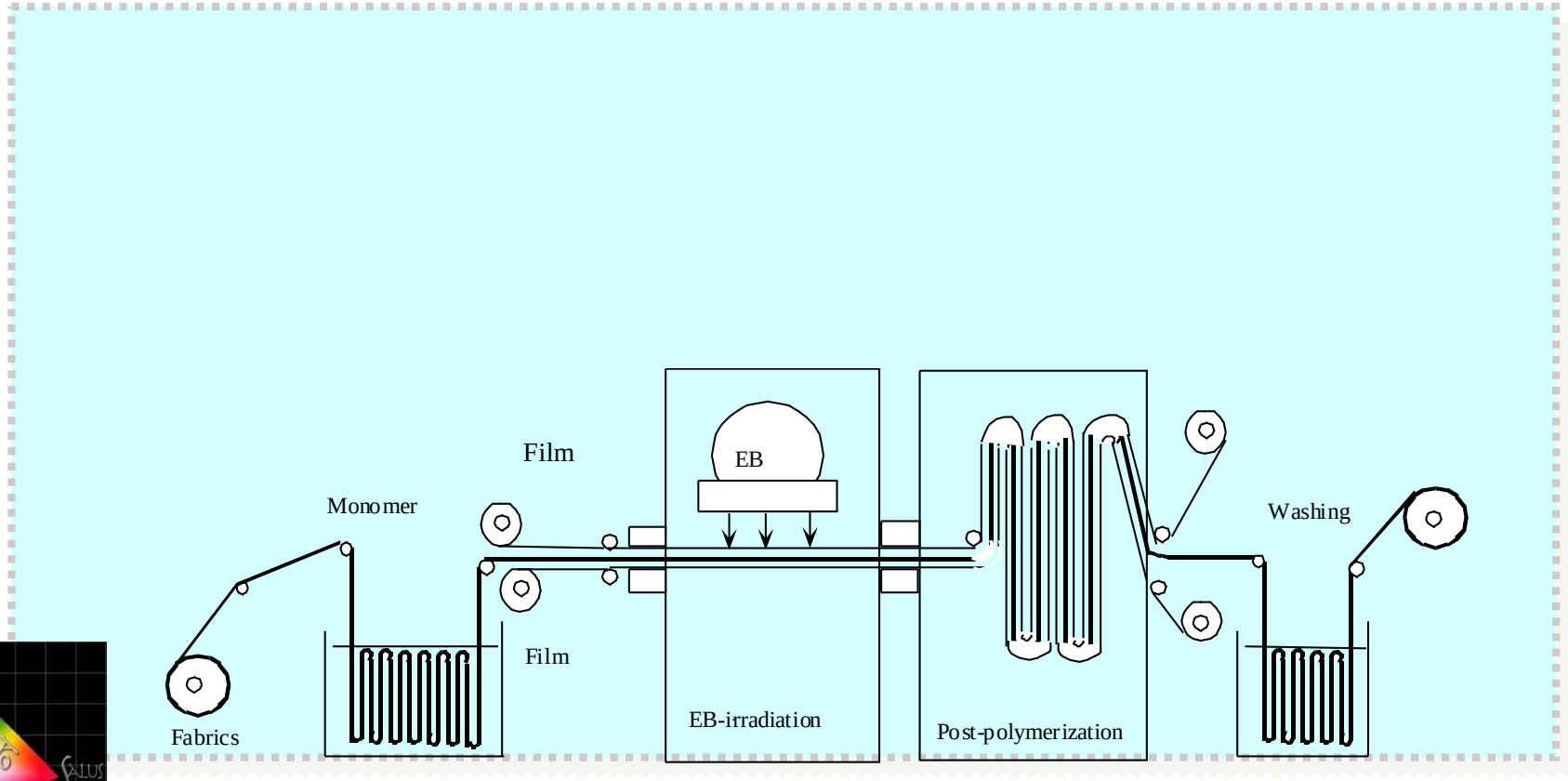






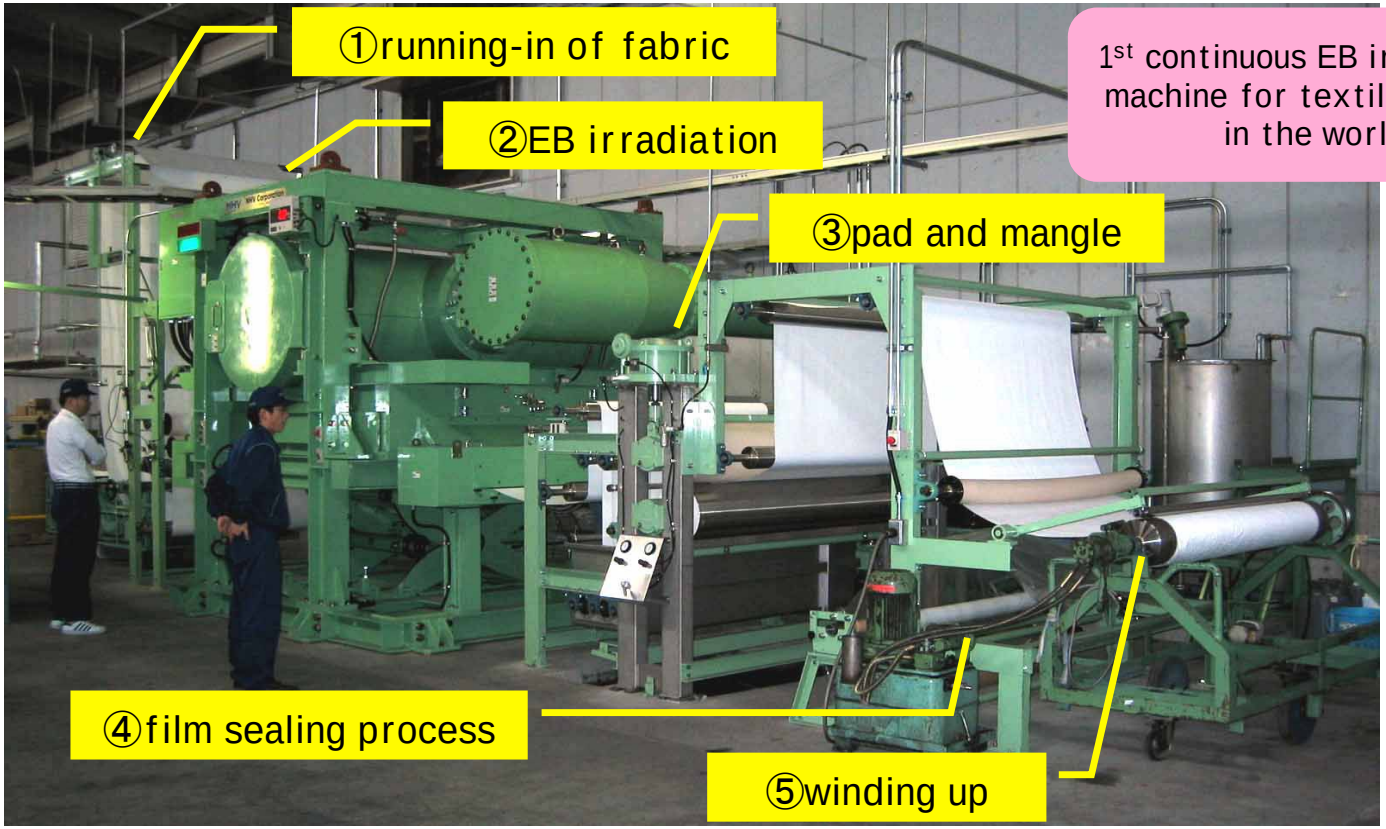
Continuous EB treating machine for textile fabrics

- Film seal method: (Japan Pat. 3005796, 3293031)
- Preparation of metal ion absorable fiber (Japan Pat. 2002-18283)
- Continuous EB traeting machine for textile fabrics
  (Japan Pat. 2005-060894, 2005-060555, 2004-376295



Practical EB irradiation machine for continuous Textile treatments

Pre-irradiation/padding/mangle/film seal/winding up/(reaction/washing/drying)

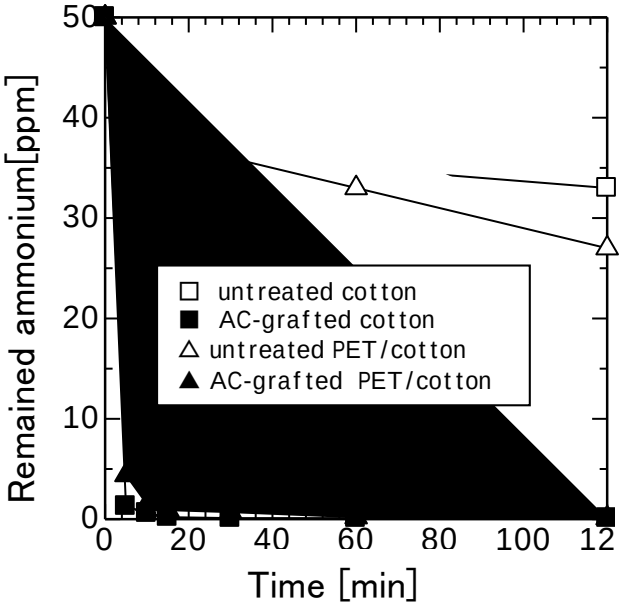


Speck

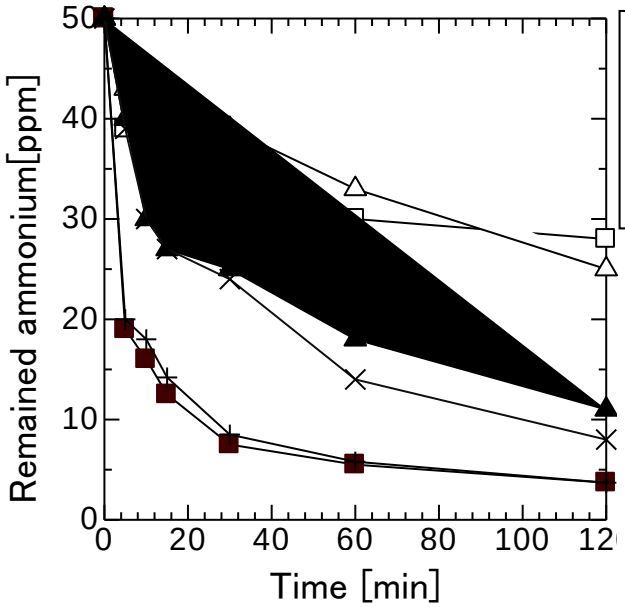
fabric width : 1,600mm
max. treatment : 1,000kGy m/min
homogeneity of EB : ±7.5%
max. acceler. Voltage : 200kV
running speed : 10~70 m/min

Deodorant function of acrylic acid grafted cotton

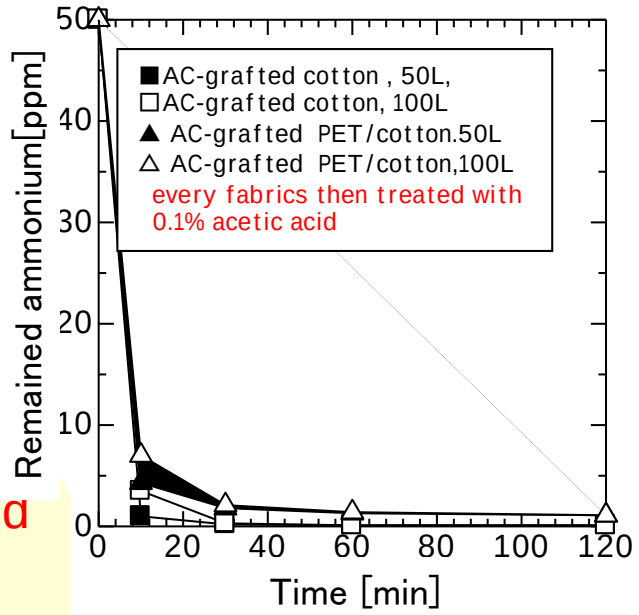
Quick-acting deodorant for ammonium



△no washing



△after 50 and 100 washing



△washing and acid treatment

After laundry the deodorant effect decreased because of Ca adsorption.
But, this is recovered by acid treatment.

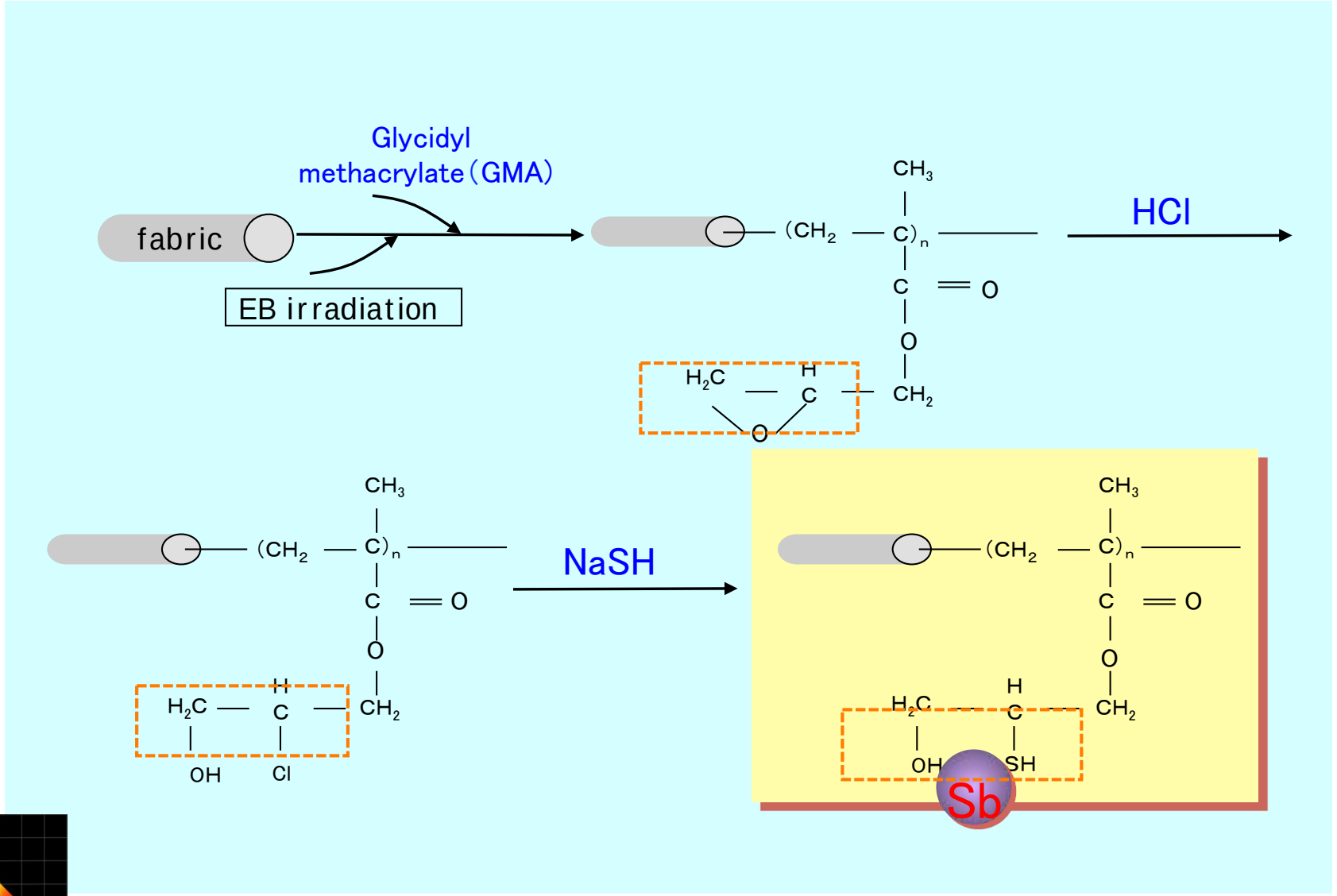
Sample preparation using deodorant fabric

Working shirts(cotton)

Working pants (PET/cotton)

Formal suits (triacetate)

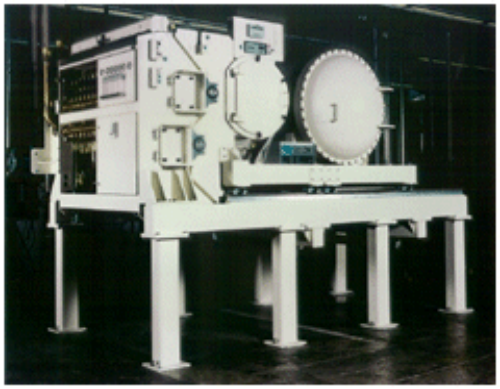
Preparation of Sb ions absorbable fabric



Third dimensional fabric for removing Sb ions from waste water

(1) Three dimensional cellolose/PVA fabric (stregnthened by PET yarn)

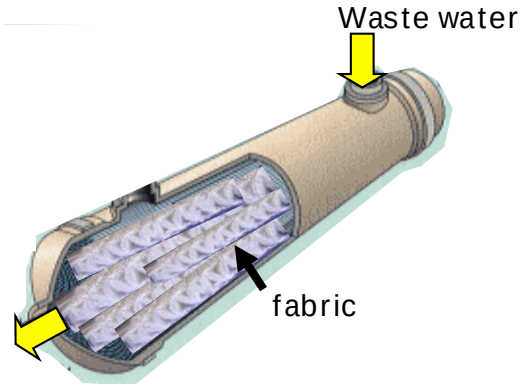
(2) EB irradiation to graft GMA(epoxy rings) in cellulose



(3) Chemical modification of epoxy ring by chemicals using dyeing machine

?

(4) Making cartridge

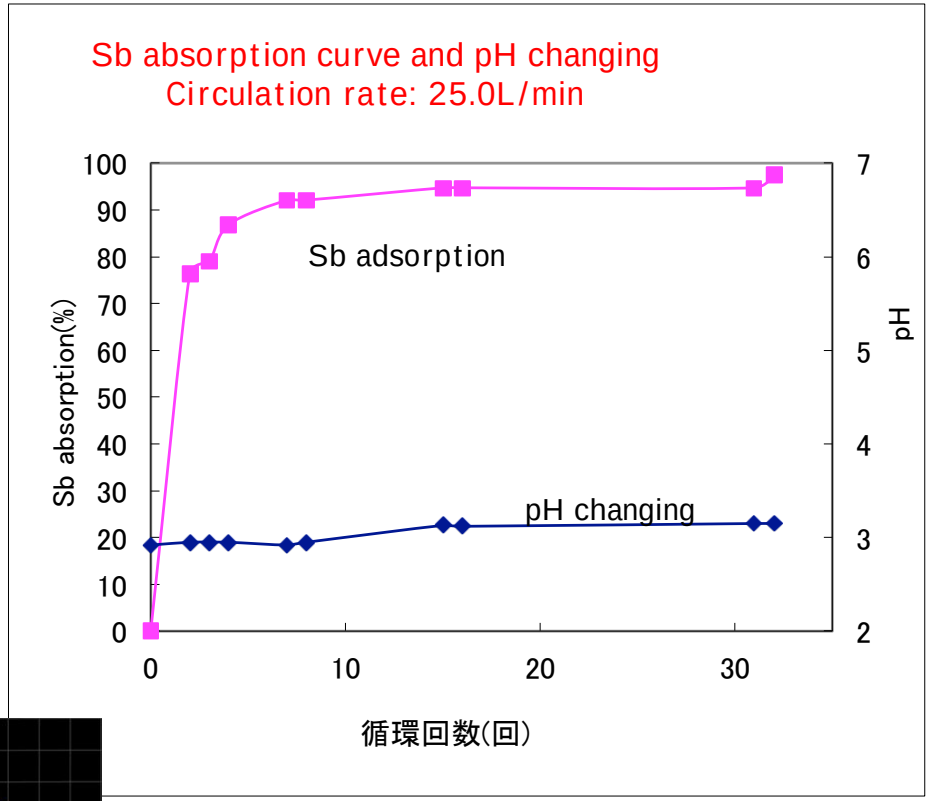


(5) Mini plant to remove Sb

Test results using waste water from dyeing factory

Grafting: 55% conditions

1) 4 cartridges (20kg fabric)
2) Waste water 3.6Ton(Sb 1.0ppm)
3) Flow rate 60 L/min (3.6Ton/hr): circulated



Circulation times	Sb濃度 ppm
0	0.38
2	0.09
3	0.08
4	0.05
7	0.03
8	0.03
15	0.02
16	0.02
31	0.02
32	0.01


Thanks for your
kind attention
Echizen Seaside