Research Opportunities in Rubber Gloves *

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*For Educational Purposes only

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Types of Unsupported Rubber Gloves

1) Disposable – a) Medical – i) Examination gloves; ii) Surgical gloves
   b) Non-medical gloves – Examples: i) Cleanroom
   ii) Food handling
   iii) Pharmaceutical / Life Sc
   iv) Janitorial
   v) Hair-dressing
   vi) General purpose

2) Reusable – Non-medical gloves – Examples: i) Chemical resistant gloves
   ii) Automobile
   iii) Agriculture & Fishery
   iv) Semiconductor
   v) Food processing
   vi) Household

Objectives of this Presentation

- Malaysia is the world's largest rubber gloves exporting country
- Market share more than 60%
- Sales value of approximately 47 billion Ringgits in 2022*
- However, the research interest among the local researchers is not high.

Objectives of this presentation are:

- To encourage more rubber glove research among the local researchers
- To provide some specific ideas on the areas of research

*https://www.statista.com/statistics/643463/sales-value-manufactured-rubber-gloves-malaysia/

Manufacturer Requirements

1) Online hole detection & “hole repair”

- Current status:
- Perform in process quality control via water leak or air inflation
- Problems: 1) Labour intensive and slow
  2) Based on sampling only. Not all gloves are tested
  3) More stringent during in-process testing, more gloves are used
  4) Water leak tested gloves require drying; inflated glove stretched > may cause damage to the gloves
- If hole in glove can be detected online, it will contribute to:
  1) Cost saving;
  2) Time-saving;
  3) All gloves are tested
- Repairing glove holes online reduces rejects

Manufacturer Requirements

2) Curing System

- Current status: Accelerator & sulphur are used for crosslinking natural rubber & polyisoprene
- Problems: 1) Accelerator could cause skin reactions, formation of nitrosamines
  2) Accelerator is cytotoxic, unable to meet ISO10993 Part 5
- Accelerator-free systems: Difficult for natural rubber & polyisoprene latexes

- Alternatives – 1) Peroxide or hydroperoxide curing systems (in molten salt)
  2) Irradiation curing systems
- Example 1: Peroxide + Irradiation (Nuclear Malaysia)

https://www.researchgate.net/publication/334547792

Manufacturer Requirements

2) Curing System for Polyisoprene and Natural Rubber

Example 2: The invention relates to method for producing a crosslinked elastomer by radiating a polymer dispersion of at least one crosslinkable polymer with electromagnetic radiation in the ultraviolet (UV light) and/or visible spectral range, wherein the crosslinking is performed in at least two stages as pre-crosslinking and post-crosslinking and at least one photoinitiator is added to the polymer dispersion to trigger the crosslinking reaction prior to the pre-crosslinking. At least one photoinitiator is added once again to the pre-crosslinked polymer dispersion prior to and/or during the post-crosslinking, and the post-crosslinking is also performed with electromagnetic radiation in the ultraviolet (UV light) and/or visible spectral range.

Method for producing a cross-linked elastomer US Patent 8673993 (2014)

<u>Manufacturer Requirements</u>

3) Powder-free System

- Coagulant normally contains powder (calcium carbonate) for producing powdered glove or washed off in post processing step, e.g. chlorination
- Current status: Metal stearates, e.g. stearates of potassium, calcium, and zinc are also used in coagulant to produce powder-free gloves

Problems: a) Stearates are not good enough for double gloving
b) Former contamination and wetting are still the issues.
c) Not suitable for cleanroom gloves

- A new powder free glove production system is desirable

<u>Example</u>: The emulsion polymerization of nitrile latex was conducted in presence of a degraded polysaccharide having a DE (Dextrose Equivalent) of 2 to 90 measured according to ISO 5377. The glove made from this latex does not require surface treatments (both inside & outside!). US Patent 10,377,882 (August 13, 2019)

Manufacturer Requirements

4) Thin Natural Rubber (NR) Examination Glove

- Gloves are sold by piece, not by weight
- Thinner gloves reduce product cost, provide good sensitivity to user
- Current status: Nitrile exam gloves can be as thin as ≈ 0.04mm
- Problems: a) Natural rubber exam gloves are much thicker, around ≈ 0.06mm
  b) Lower thickness NR glove tends to have thin spot and film issues
- Thinner NR gloves will be well received by the industry
- Reason for NR gloves being thick: Possibly larger particle size
- Particle size of nitrile is 8-10 times smaller than NR latex
- NR condoms can be thin due to the symmetrical shape of the product
- For gloves, may have to use different types of former material, or additives to improve film formation

Manufacturer Requirements

5) Polymer coating for cleanroom gloves

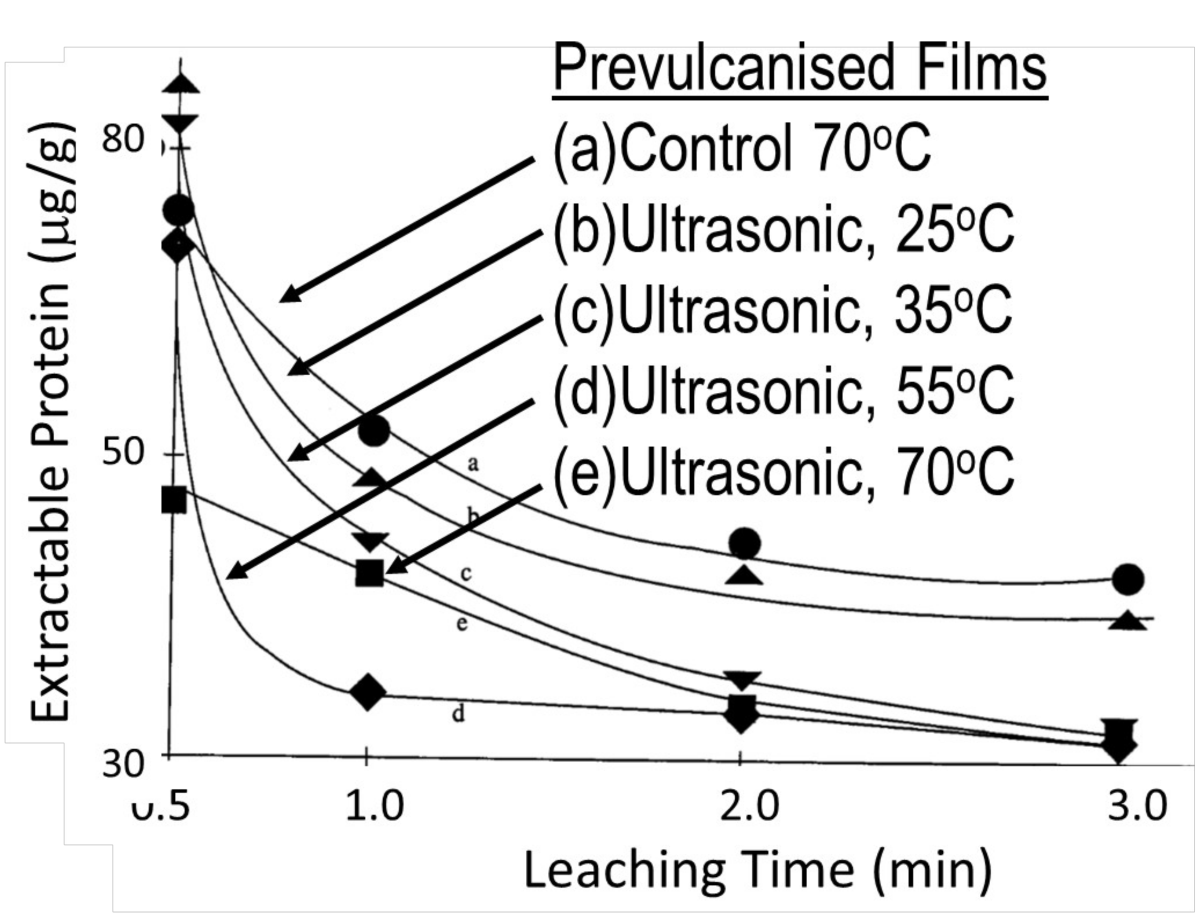
- Polymer coating is used for antitack and glove donning
- Cleanroom gloves require extensive washing
- Currently, chlorination is being used for the surface treatment
- Current polymer coating systems produce particles during washing, not suitable for cleanroom gloves.
- New polymer coating systems for the cleanroom gloves are needed

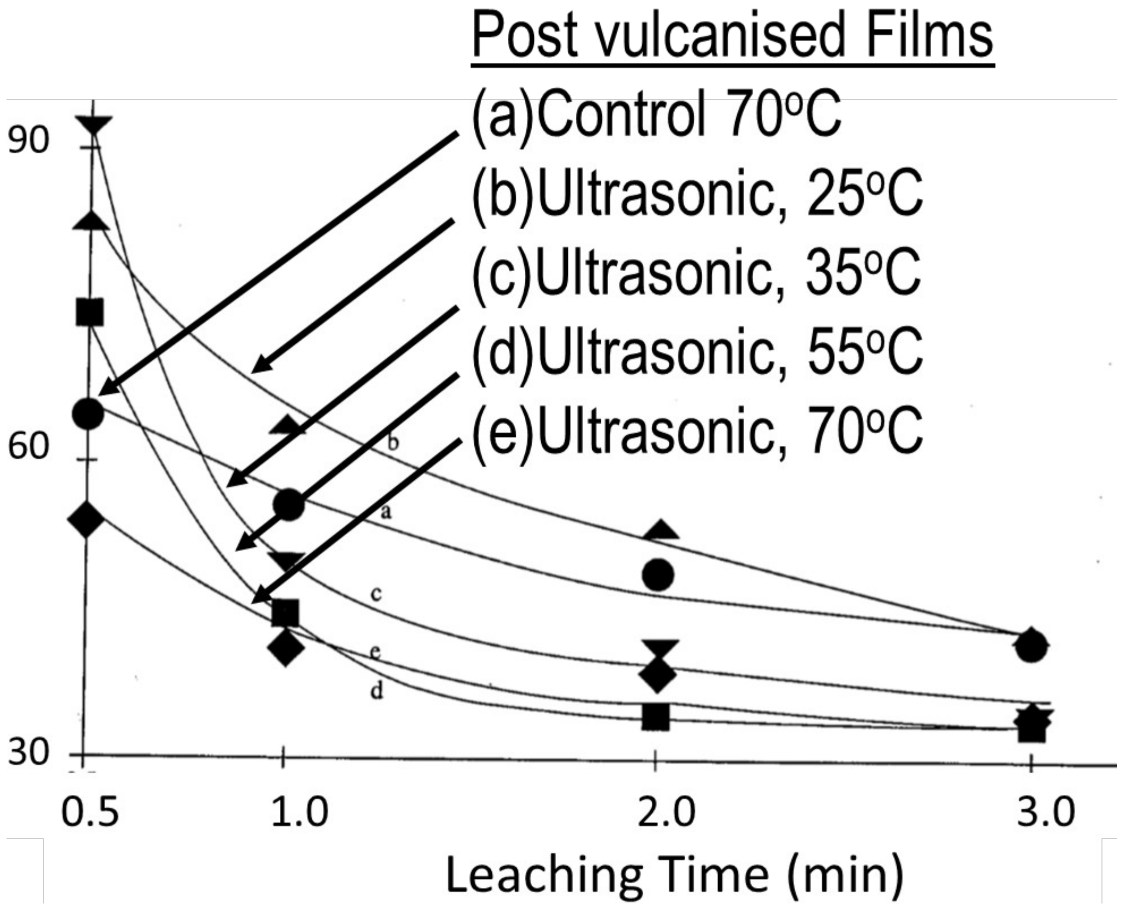
Manufacturer Requirements

6) Efficient Leaching System

- Leaching, a cleaning process, removes unwanted non-rubber materials, such as surfactants, proteins, coagulant
- Less odour, lower skin unfriendly materials, e.g. accelerator, proteins
- Also promotes inter-particle integration > improves tensile properties
- Current status: 1) Two stages: Before curing (pre-leach, 50-70^{o}C) and after curing (post-leach, 80-90^{o}C)
  2) Continuous topping up of fresh water, draining dirty water
- Problem: Consumes water and power
- A higher efficiency leaching reduces water and power consumption
- Better efficiency at high temperature, agitation, slightly higher pH, correct flow
- New methods of high efficiency leaching are needed.

Example: Dry film ultrasonic leaching (Post leach)





Journal of Rubber Research (1999) 2(1):23-28

http://vitaldoc.lgm.gov.my:8060/vital/access/services/Download/vital1:23736/ARTICLE

Manufacturer Requirements

7) Porous glove former restoration

- Glove former normally lasts for several months to several years, glove thickness dependent
- Alkalis are corrosive to ceramic former, causing it to become porous over time
- Currently, no method available to restore the porous former
- Replacement of glove former is a high cost exercise
- Restoration of porous former – highly appreciated by the industry

User Requirements

1) Chemical permeation for Personal Protection Equipment (PPE)

Current rubber gloves (nitrile, polychloroprene and natural rubber) are unable to pass chemical permeation of

a) 96% Sulphuric acid,

b) 65% Nitric acid,

c) Tetrahydrofuran,

d) Dichloromethane,

e) 40% Hydrofluoric acid

When tested according to EN16523-1

User Requirements

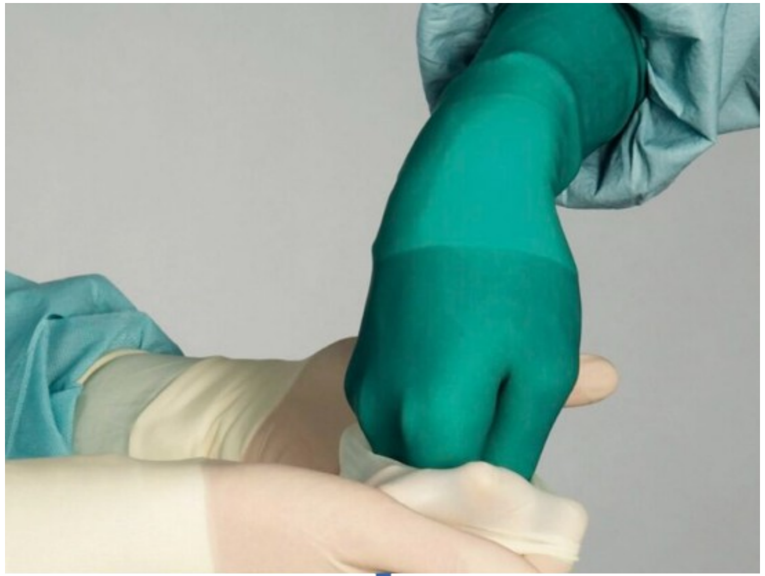
2) Bone cement (acrylic monomer) resistance

- Bone cement is used to hold broken bone in shape by orthopaedic surgeons
- Current status: 1) No medical glove in the market can prevent permeation of bone cement (Usually permeate in less than 10 minutes).
  2) User who are allergic to bone cement normally wears 2-3 gloves and changes regularly to prevent permeation
- Problems: 1) Frequent replacement of surgical glove interrupts the medical procedure
  2) Some users are allergic to bone cement
- A bone cement resistant glove is expected to be well received by the users

User Requirements

3) Better breach detection

- A breach detection system alerts the user when the glove has a hole.
- Most of the users are unaware of glove breach during use.
- Current status: Combination of darker under glove and brighter outer glove. A breach will be detected when liquid penetrates through the hole and the colour of wetted under glove become more visible.
- A better breach detection to inform the user glove breach during use is helpful



User Requirements

4) Glove with super hydrophobic surface (instead of antimicrobial)

- Improves visibility of gloved fingers during a procedure, e.g. stitching
- Reduce or prevent contact transfer of pathogens from surface to surface
- Current status: No such glove in the market

Example**:** The article contains an elastomeric base and a fluid-repellent coating composition that effectively repels both hydrophilic and lipophilic liquids from its surface and inhibits cross-contamination of surfaces. Articles prepared in accordance with the invention reduce the risk of contamination associated with blood and other body fluids, as well as reduce fluid-based visual obstruction and enhance the clarity of medical procedures

Repellent elastomeric article , US Patent 8,530,016 Sept 10, 2013

User Requirements

5) Improve comfort

- Sweat reduces the comfort of glove use
- Ability to remove / reduce sweat of user during use, improves comfort
- Either through absorption or transmission (e.g. polyurethane)

Example: A disposable surgical glove comprising a first thin elastomeric layer (1); and a second layer (3) to having a securely bonded, or laminated fabric liner (3) so that the second layer (3) is configured to absorb, excess perspiration or moisture of the skin, wherein both layers (1) (3) are held evenly together by a coagulant and bonded by an adhesive chemical, such that the elastomeric glove (1) and fabric liner (3) may be stretched to whatever extent, without affecting its lamination, and method of manufacturing with the use of a skeletal rubber former (2).

World Intellectual Property Organization WO2010107297 23 September 2010

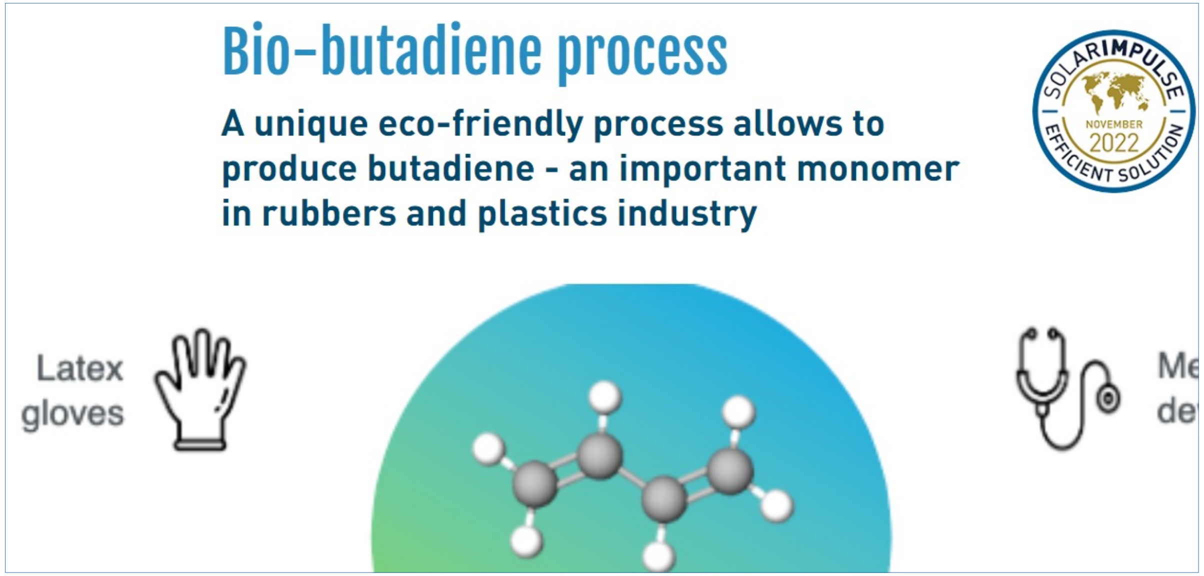
Other Requirements

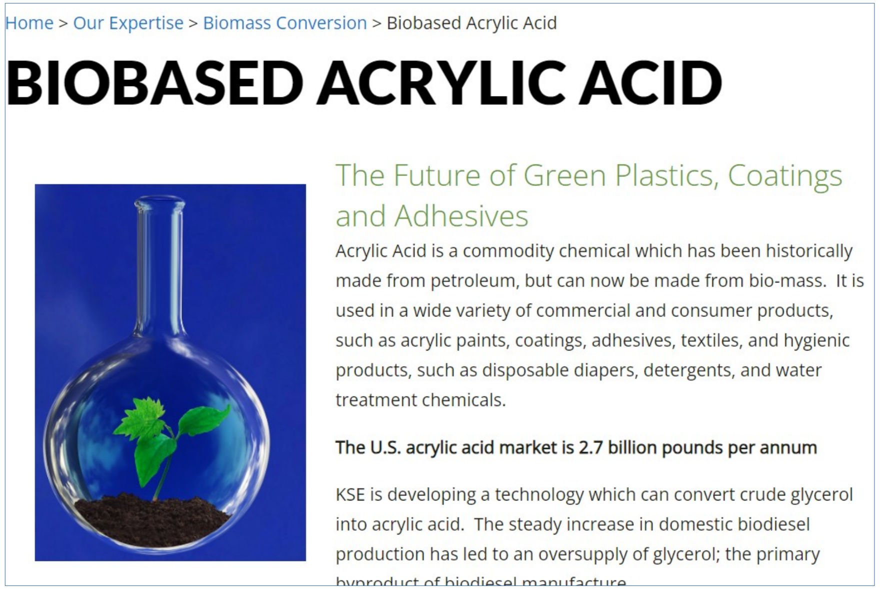
1) Sustainable materials

- Examples: bio-monomers for the rubber synthesis, chemicals such as surfactants, curing agents
- Need cost effective methods of production

2) Less materials

- Examples: Soap-free latex, dispersing agent free compounding ingredients
- Need cost effective methods of production





Home > Our Expertise > Biomass Conversion > Biobased Acrylic Acid

BIOBASED ACRYLIC ACID

The Future of Green Plastics, Coatings and Adhesives

Acrylic Acid is a commodity chemical which has been historically made from petroleum, but can now be made from bio-mass. It is used in a wide variety of commercial and consumer products, such as acrylic paints, coatings, adhesives, textiles, and hygienic products, such as disposable diapers, detergents, and water treatment chemicals.

The U.S. acrylic acid market is 2.7 billion pounds per annum

KSE is developing a technology which can convert crude glycerol into acrylic acid. The steady increase in domestic biodiesel production has led to an oversupply of glycerol; the primary byproduct of biodiesel manufacture

General Commercial Interest

- Easy operation, preferably no machine modification
- Simplifying production process, e.g. reduce manual operation
- Low cost. Disposable products are cheap. Cost-benefit balance
- Fast return of investment
- Preferably no drug-device combined products, e.g. antimicrobial agent
- Improved product performance, safety of user
- Preferably working principle / mechanism is known via feasibility study
- Materials commercially available, preferably no nano-materials (for medical)
- Reduce defects, waste, effluent discharge
- Improve health e.g. skin friendliness, biocompatibility
- Increase through put, reduce time, increase efficiency

Some General Recommendations for GFRI Application

- Related prior art search, patent list, not just journals
- Feasibility study; relevant experience
- Extent of invention applications, discuss with the relevant industry players
- Reasonable grant size, not necessary maximum
- Reasonable duration
- Collaboration with industry partners, an added advantage

End of Presentation. Thank You for Your Attention