Chemical gloves

The devil is in the details.

Daniel R. Kuespert, PhD, CSP
Homewood Laboratory Safety Advocate

JOHNS HOPKINS
UNIVERSITY

Recent incidents at JHU

- H_2S exposure/Bloomberg
  - Materials synthesis
- Fire/AML/Wyman Park
  - Laser cutter/foamcore
- Exotic needlestick/Remsen
  - Needle blow-off
- Liquid N_2 exposure/Remsen
  - Replacing Dewar on Schlenk line trap
- Glassware serious injury/Croft
  - Catching a dropped beaker

1. **What similarities do these incidents have?**
2. **What might have prevented the incidents?**
3. **What caused the incidents?**

Safety classes at JHU

- Formal
  - EN.500.601 (1cr): *Research Laboratory Safety*
  - EN.540.490 (1cr): *Intro to Chemical Process Safety*
- Informal
  - Pretty much any topic
  - Currently developing *Cryogen Safety* seminar

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KIMBERLY-CLARK* Nitrile Glove Chemical Resistance Guide

The Science of Protection.

Use the color code rating system below with the chart at right to determine the chemical compatibility for incidental exposure.

GREEN

The results for this specific chemical suggest that the glove would provide an adequate barrier for use in most applications.

A glove/chemical combination receives a GREEN rating if:

- The permeation breakthrough time is excellent or good and the chemical has high volatility.

OR

- The permeation breakthrough time is excellent and the chemical has low volatility.

YELLOW

The results require additional consideration to determine suitability for use.

A glove/chemical combination receives a YELLOW rating if:

- Any glove/chemical combination does not meet either set of conditions required for a GREEN or RED rating.

RED

Not recommended for use.

A glove/chemical combination receives a RED rating if:

- The permeation breakthrough time is poor and the chemical has low volatility.

OR

- The permeation breakthrough time is not recommended and the chemical has either high or low volatility.

Chemical Name	Permeation Time (minutes) *ASTM F739-99A*	Permeation Rate (pg/cm²/min) *ASTM F739-99A*	Concentration	Color Code Rating
Acetaldehyde	<1	353	99.5%	
Acetic Acid	5	482	99.7%	
Acetone	1	466	99.5%	
Acetonitrile	1	329	99%	
Acrylic Acid	1	57.8	99%	
Ammonium Hydroxide	7	395	30%	
Amyl Acetate	4	261	99%	
Analine	7	74.7	99.5%	
Benzaldehyde	78	0.57	99.5%	
Benzene	<1	627	99.8%	
Benzyl Alcohol	5	86.8	99%	
n-Butanol	10	5.99	99.8%	
Butyl Acetate	3	233	99%	
Carbon Disulfide	2	3.81	99%	
Carbon Tetrachloride	5	48.9	99.5%	
Chloroform	1	958	99%	
Citric Acid	>480	Not Detected	50%	
Cyclohexane	>480	Not Detected	99.7%	
Cyclohexanol	112	1.18	99%	
Cyclohexanone	1	787	99.8%	
d-Limonene	107	0.157	97%	
n-Dibutyl Phthalate	>480	Not Detected	99%	
1,2-Dichlorobenzene	<1	1179	99%	
Dichloromethane	1	2006	99.9%	
Diesel Fuel, mixture	160	0.63	Mixture	
Diethyl Ether	1	595	99.9%	
Diethylamine	<1	587	99.5%	
Di-isobutyl Ketone	10	1141	80%	
Dimethyl Sulfoxide	8	501	99.90%	
Dibutyl Phthalate	>480	Not Detected	99%	
1,4-Dioxane	<1	707	99.4%	
Ethanol	7	296	99.5+%	
Ethanolamine	>480	Not Detected	99%	
Ethidium Bromide	90	0.68		
Ethylene Glycol	>480	Not Detected	99.8%	
Formaldehyde	110	0.172	37%	
Formic Acid	6	0.554	88%	
2-Furaldehyde	<1	385	99%	
Glutaraldehyde	>480	Not Detected	50%	
n-Hexane	16	55.3	99+%	
Hydrazine	31	40.2	98%	

What we'll cover

- Why it's not so simple—the complications
- How to determine which glove to use
- Concerns for which to watch out

Why choosing gloves is hard

Chemical resistance of gloves depends on:

Chemical properties

- Identity
- Concentration

Glove properties

- Material
- Thickness
- Surface quality
- Overall quality

Material properties

- Breakthrough time
- Permeation rate
- Physical resilience

Mode of use

- Possible contact
- Mechanical abuse
- Motion/flexing

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Kimberly-Clark, Inc.

Chemical identity

- Manufacturers test a limited number of chemicals against their gloves.
- ChemWatch Gold SDSs have computer-predicted “glove selection index”.

Recommended material(s)

GLOVE SELECTION INDEX

Glove selection is based on a modified presentation of the:
"Forsberg Clothing Performance Index".
The effect(s) of the following substance(s) are taken into account in the ***computer-generated*** selection:
ACETONITRILE

Material	CPI
BUTYL	A
BUTYL/NEOPRENE	A
CPE	A
PE/EVAL/PE	A
PVA	A
SARANEX-23	A
NEOPRENE	B
TEFLON	B
NATURAL RUBBER	C
NATURAL+NEOPRENE	C
NITRILE	C
VITON/NEOPRENE	C

* CPI - Chemwatch Performance Index
A: Best Selection
B: Satisfactory; may degrade after 4 hours continuous immersion
C: Poor to Dangerous Choice for other than short term immersion
NOTE: As a series of factors will influence the actual performance of the glove, a final selection must be based on detailed observation. -
* Where the glove is to be used on a short term, casual or infrequent basis, factors such as "feel" or convenience (e.g. disposability), may dictate a choice of gloves which might otherwise be unsuitable following long-term or frequent use. A qualified practitioner should be consulted.

ChemWatch SDS for acetonitrile

Concentration

- Not every concentration is tested.
- Some gloves good at low concentration fall apart at higher concentrations.

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Kimberly-Clark, Inc.

Glove material

- Many different materials used
- Same material may be different between manufacturers or even models of glove!
- **Do not trust** glove chemical resistance data for other gloves.

Lab Depot, Inc.

Glove thickness

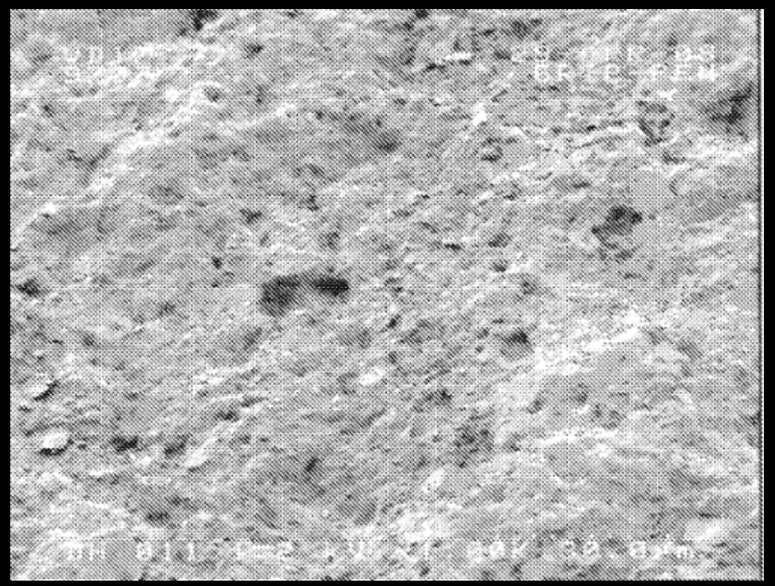
- Thicker material resists chemicals longer—usually.

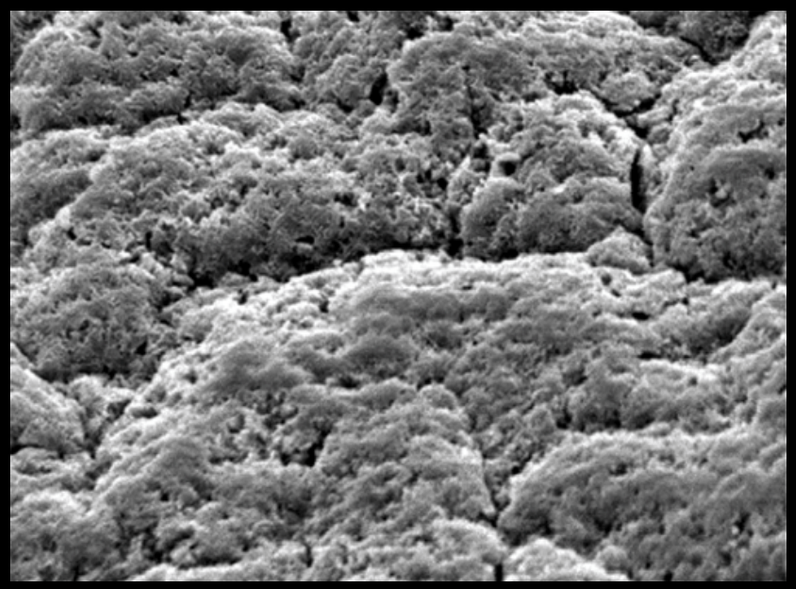
- Thicker material means less dexterity.

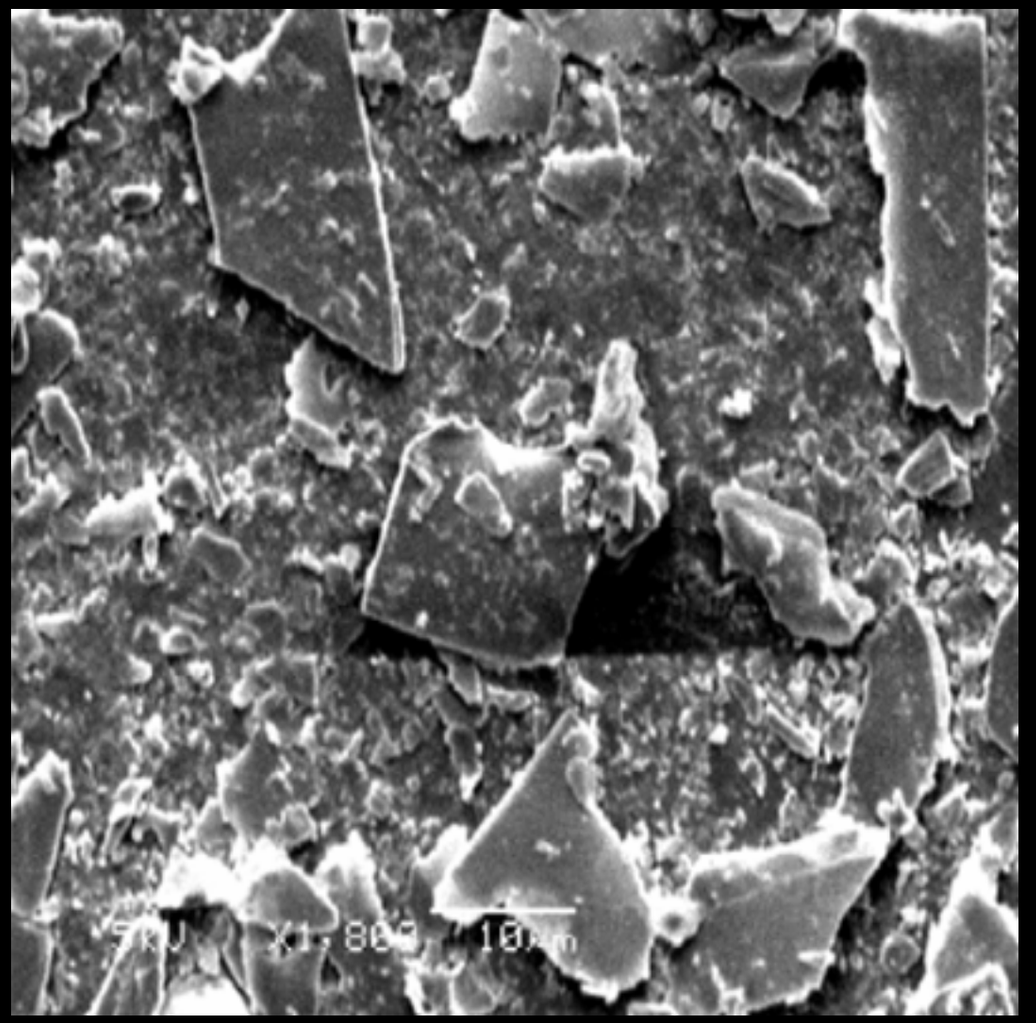
Dow DuPont

Lab Depot, Inc.

Surface quality





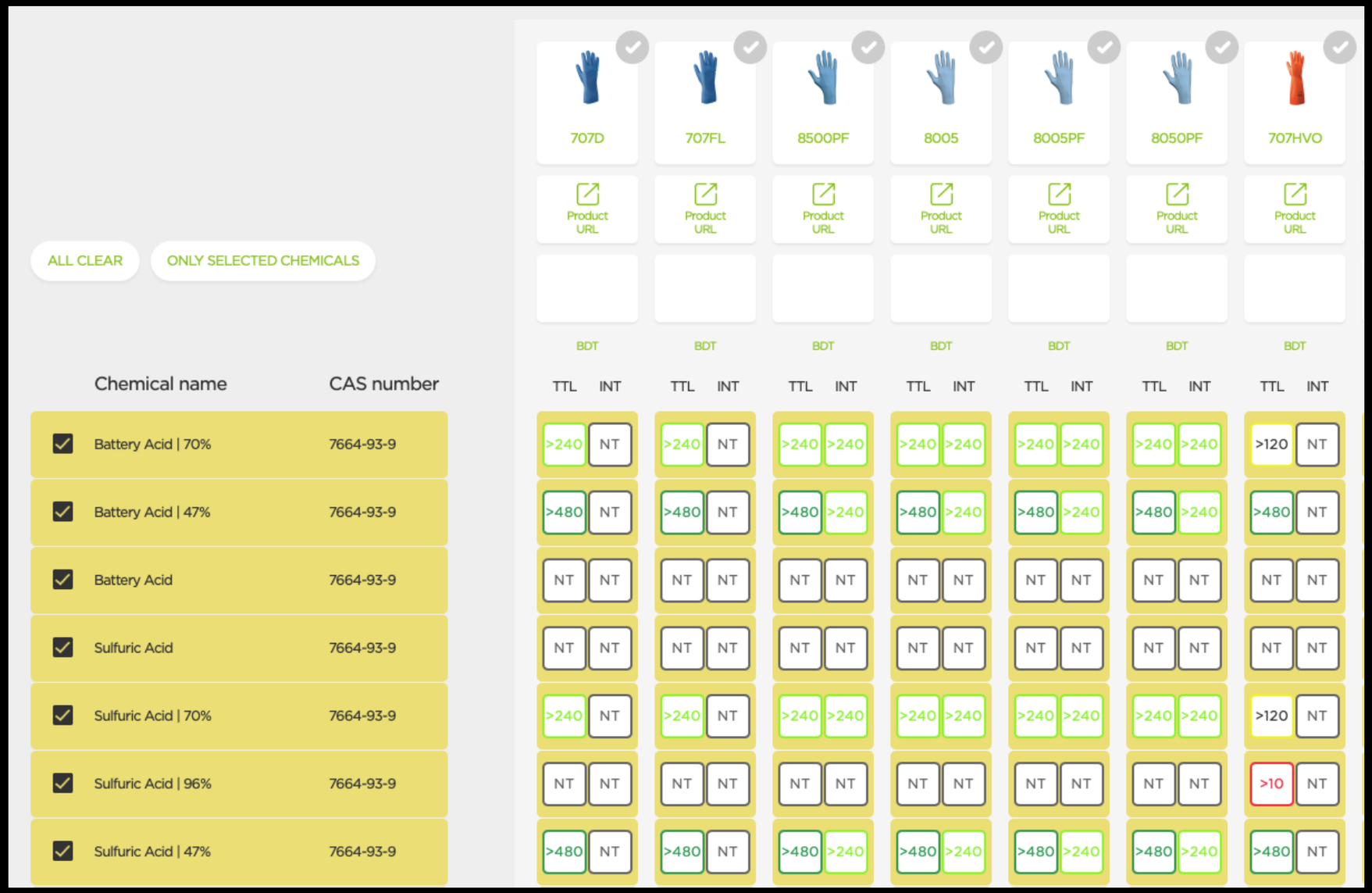


Glove quality

- Cheap gloves are cheap for a reason.

EagleProtect.com

Breakthrough time



Breakthrough time is the amount of time it takes for the first molecule of chemical to penetrate the glove.

Showa/Best Gloves

Permeation rate

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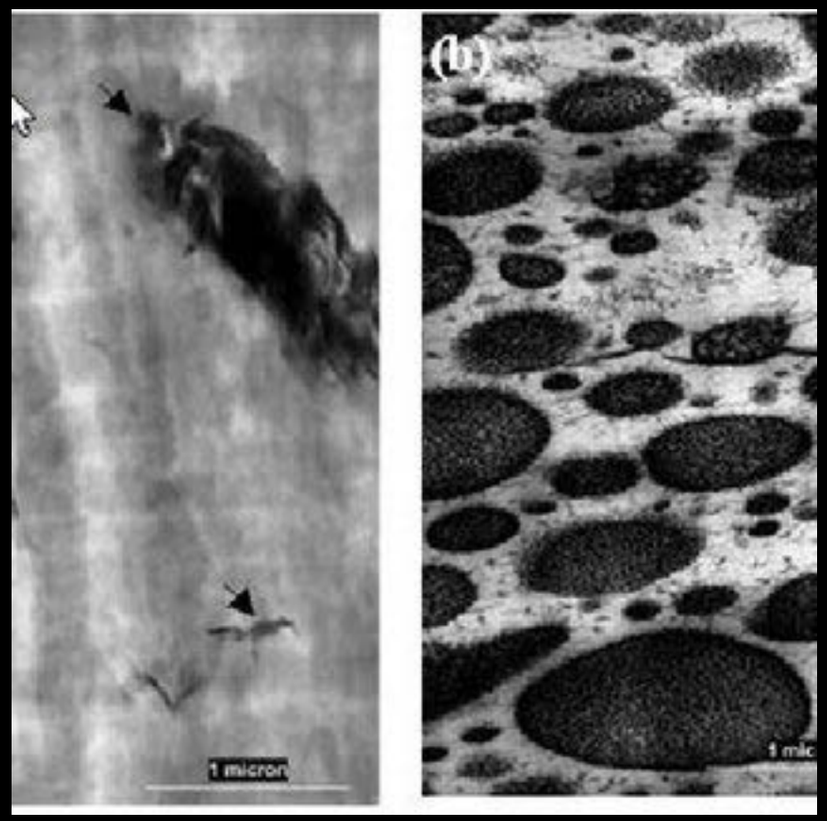
Kimberly-Clark, Inc.

Permeation rate is the steady-state rate at which chemical is transported through the glove material.

Glove resilience

- Glove materials degrade with chemical contact.



Abd Razak, S.B. *J. Natural Sciences Research* **4**(3) 2014.

Possible contact

- Direct chemical immersion
- Intermittent chemical contact
- Chemical splash contact

Mechanical abuse

- Sharps-handling can put invisible holes in gloves
- Wearing too small a size can stress the glove

Motion/flexing

- Even just flexing your hand degrades the glove performance

What glove to use?

Always

- Choose BT > 3 x (the time you’ll wear the glove)

Direct chemical immersion

- No exam gloves
- Choose as long a BT as available
- Discard before BT reached

Intermittent contact

- Choose BT based on work time

- Sometimes can use shorter BT if PR is low relative to chemical toxicity—ask an industrial hygienist

Splash contact

- Very toxic substances
  - Double-glove
  - Engineer experiment to minimize contact
- Will you know you’re splashed?
  - YES: Shorter BT is tolerable
  - NO:
    - Choose BT > 3 x (work time)
    - Inspect gloves after use and discard if signs of contact

Special concerns

Cheap gloves

- Often contain fillers like $CaCO_3$
- These can improve properties in some cases
- Excess filler hastens degradation, though

Latex gloves are not the only gloves that cause allergic reactions

- Carbamates and thiazoles used in latex, nitrile, vinyl can be allergens

- Anaphylactic shock reactions have occurred

“Powder-free” gloves are not necessarily clean

- Processes to remove powder can leave residual chemicals

DO NOT TRUST another manufacturer's data

- There are several ways to process a glove
- These produce different BT, PR, resilience
- Fillers differ, surface treatments differ, and base polymer differs

BT/PR vary widely from lab to field

- Vinyl gloves often have so much plasticizer that they begin leaking immediately upon donning

- Quality issues like microscopic pores and surface imperfections in nitrile gloves are often not visible

- BT can drop 31% with movement like pipetting, so use a 3x safety factor

What we covered

- Why it’s not so simple—the complications
- How to determine which glove to use
- Concerns for which to watch out

Thanks for listening!

I would be glad to take any questions now.

JOHNS HOPKINS
UNIVERSITY

Close calls

- “Almost-accidents:” no injury or property damage (including business interruption)
- Report close calls to closecalls@jhu.edu
- Close calls lead to incidents

Tell your close-call story

- What happened?
- Was it really a close call or was it an incident?
- What could have happened?
- What were the causes?
- How could you prevent future occurrences?
- Were there higher-level things to address?