LabAlliance Instruments Solution for Determination of Protective Material Resistance to Permeation by Chemicals

Introduction

The performance of chemically protective clothing, glove material or foot-ware can be assessed by the study of degradation, penetration, and permeation. Degradation is the reaction of challenge chemical with protective material that causes changes in physical or chemical properties of the material. Some common observable impacts of degradation on protective material include: swelling, shrinkage; color change; becoming harder or softer, stiffer, or brittle; and texture deterioration and weakness.

Penetration is defined as the flow of bulk liquid through seams, gaps, holes, zippers, openings or closures. No Chemical, molecular, or mechanical change in the protective material are required for penetration. *Permeation* by contrast, is defined as the process by which a chemical moves through protective material at the molecular level. It consists of three consecutive phases: absorption of the permeant into the external portion of the protective material, diffusion of the permeant through the protective material, and desorption of migrated molecules from the inside portion to the collection side.

Glove manufacturers conduct permeation tests on their products and provide information about NBRT and SSPR for different chemicals and solvents. Almost all permeation studies by glove manufacturers apply ASTM F739 and/or EN16523-1/2:2015 (supercede EN 374-3:2003) permeation standards as reference.

This method provides test results in terms of breakthrough time. This parameter is a key measure of effectiveness of a material act as a barrier to the challenge chemicals.

Experimental & Material

The ASTM F739 standard has been known as the most frequently applied standard method in the USA for evaluating permeation resistance of protective clothing, especially gloves. The test method consists of a cell with two glass chambers, one as the permeant chamber, which contains challenge analyte, and is in direct contact with the outer surface of the glove specimen.

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Another permeation standard developed by the European Union (EN) is EN 16523-1:2015 and 16523-2:2015 (supercede 374-3:2003). This EN method uses two-chamber permeation cells with a 51 mm diameter for challenge and collection solutions, similar to ASTM 739 cells. The permeation cells developed by EN 16523 also have similar features to the ASTM F739 cells. The ASTM F739-12 recommends 5 chamber volumes per minute as the minimum required flow rate for all permeation sets with a dynamic liquid flowing collection 12 medium such as open loop systems (with a gaseous collection media) and closed loop systems (with a dynamic liquid collection media).

The standard states that chemical resistance glove shall have at least performance Level 2 when tested against three chemicals taken from the list of chemicals outlined in ASTM Guide F1001.

Both EN and ASTM standard method allow a variety of options in analytical technique and collection media. At LabAlliance Instruments, we utilize closed loop system for liquid chemicals and open loop system for gaseous chemicals.

A liquid collecting medium is used for the collection of permeated molecules of a *low volatility* that are soluble in the collecting medium under the conditions of the test in sufficient quantities of analysis. Water is generally used or other liquid which does not influence the resistance of a material to permeation.

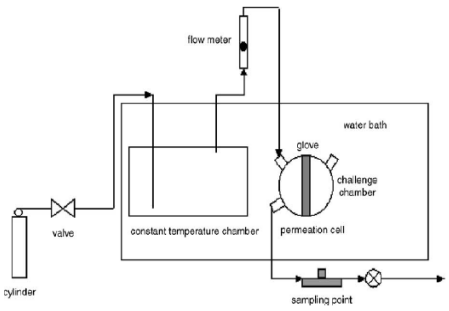
A gaseous collecting medium is usually used under continuous flow conditions for the collection of permeating molecules that are *capable of vaporizing* in sufficient quantities of analysis. The gaseous collection medium shall be a gas or gas mixture which does not interfere with the detection of the challenge chemical and does not itself permeate or degrade the material under test. The quality of gas supply shall be of a sufficient consistency over a duration of the test that changes do not interfere with detection of the challenge chemicals.

The ***LabAlliance Instruments*** Solution for measuring chemical resistance in gloves provide standard test method for measuring permeation of liquids and gases through gloves or other protective clothing materials in accordance of ASTM F739 and EN16523.

For the measurement of gaseous chemicals, the system consists of a Gas Chromatograph (GC) with auto Injector, split/splitless inlet, FIDs, valves, Permeation Cells with all necessary fitting and connection, and a tailor-made software for data acquisition and processing. For simultaneous triplicate measurements, additional quantity of operation unit will be added accordingly.

For measuring liquid chemicals, the system consists of a High Pressure Liquid Pump capable of 3 channels flow, pH/conductivity meter, Permeation test cell, fixed volume stirred reservoir, complete with all necessary fitting and connection. A tailor-made software for data acquisition and processing will be provided. For simultaneous triplicate measurements, additional quantity of operation unit will be added accordingly.

In delivering this Solution, user will be trained on operation and calibration of the complete setup, from sample preparation/conditioning to result printout.



Open Loop Permeation Cell

Agilent Technologies

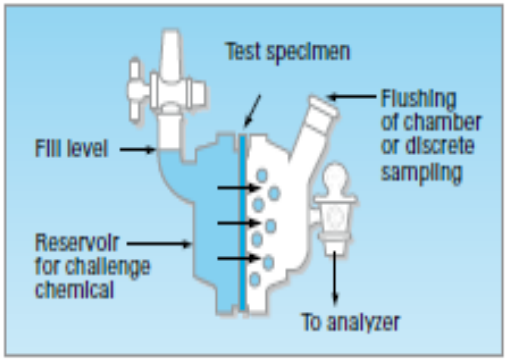
7890B Gas Chromatograph System

Table 1

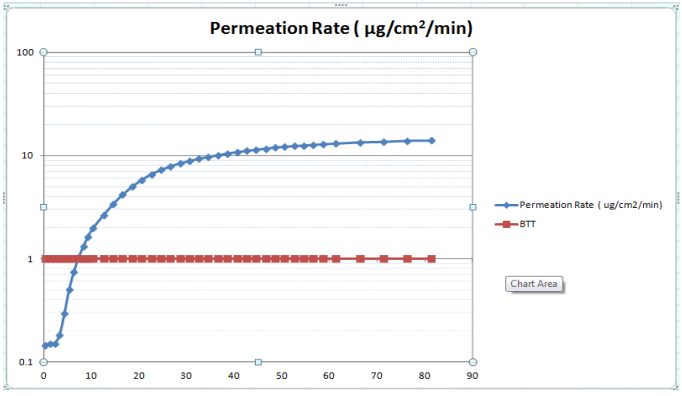
Chemical	CAS number [a]	Class	Appropriate technique(s) for the detection
Methanol	67–56–1	Primary alcohol	FTIR – PID – FID
Acetone	67–64–1	Ketone	PID – FID – FTIR
Acetonitrile	75–05–8	Nitrile compound	PID – FID – FTIR
Dichloromethane	75–09–2	Chlorinated hydrocarbon	PID – FID – FTIR - ECD
Carbon disulphide	75–15–0	Sulfur containing organic compound	FTIR
Toluene	108–88–3	Aromatic hydrocarbon	PID – FID – FTIR
Diethylamine	109–89–7	Amine	PID – FID – FTIR
Tetrahydrofuran	109–99–9	Heterocyclic and ether compound	PID – FID – FTIR
Ethyl acetate	141–78–6	Ester	PID – FID – FTIR
n-Heptane	142–85–5	Saturated hydrocarbon	PID – FID – FTIR
Sodium hydroxide 40 %	1310–73–2	Inorganic base	pH – Selective electrode - conductimetry
Sulphuric acid 96 %	7664–93–9	Inorganic mineral acid	pH – Selective electrode - conductimetry
Nitric acid (65 ± 3) %	7697–37–2	Inorganic acid	pH – Selective electrode - conductimetry
Acetic acid (99 ± 1) %	64–19–7	Organic acid	PID – FID – FTIR pH – Selective electrode - conductimetry
Ammonia solution (25 ± 1) %	1336–21–6	Alkali solution	pH – Selective electrode - conductimetry
Hydrogen peroxide with a volume fraction of (30 ± 1) %	124–43–6	Peroxide	Selective electrode – Redox electrode
Isopropanol	67–63–0	Aliphatic alcohol	PID – FID – FTIR
Sodium hypochlorite (13 ± 1) % (of active chloride)	7681–52–9	Hypochlorite	pH – Selective electrode - Conductimetry

Table 1: Appropriate techniques for the detection of different chemicals(according to ASTM Guide F1001)

This solution focuses on liquid permeation based on pH – Conductivity measurement.



Closed Loop with static liquid medium collection



LabInsight dedicated software for data acquisition and processing