

PERMEATION RATES OF SOIL FUMIGANTS THROUGH PLASTIC FILMS BY THE CUP METHOD

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Plastic films currently used during soil fumigation to control emissions have been shown to be permeable for fumigant vapors, resulting in appreciable losses to the atmosphere. However, for physicochemical properties of fumigants it is generally difficult to measure gas-permeability rates of fumigants accurately. Therefore, there is hardly information about gas-permeability of fumigants. To date, several measuring methods for gas-permeability rates of plastic films have been proposed. These methods need gas chromatograph equipments and specialized apparatuses. Agricultural extension agents and fumigators require simpler and easier methods to select plastic films, which are suitable for soil fumigation.

Here, we describe a simple apparatus useful for obtaining gas-permeability data, and the effect of temperature and film thickness. By reference to the liquid permeability test (Japanese Industrial Standards: JIS Z 0208), this approach improved the cup method, where a sample of film to be tested was set on the top of a stainless steel vessel (cross-section area: 5 cm^2 , internal volume: ca. 15 cm^3), and the upper side was left open to allow its concentration low enough and clean air was swept across the surface of a sample film; a few ml of fumigant liquids were put into vessels, gas-permeability rates were estimated from the course of gravimetric changes of fumigants every 5 seconds at several temperatures (Fig. 1). The permeability of films to chloropicrin, D-D (1,3-dichloropropene), MITC (methyl isothiocyanate), MeI (methyl iodide), PrBr (propargyl bromide) and ETOH (ethanol) were measured. This method for measuring the permeability of plastic films to fumigant vapors is under the steady-state conditions, because the concentrations of saturated fumigant vapors in experimental vessels are maintained constant depending upon the temperature (Fig. 2). The method was tested using conventional polyethylene and polyvinylchloride and gas-barrier films. Here, the measuring time is enough for gas-permeable films (e.g., polyethylene and polyvinylchloride) in 30 minutes, and 6 hours for gas-barrier films.

The quantitative limit of gas-permeability rate, which it depends on the performance of the analytical balance, measuring time, etc. is $0.009 \text{ g/m}^2/\text{hr}$ under this condition. The results of these experiments showed that gas-permeability of film greatly depended on temperature and film materials, but was relatively constant despite changes in film thickness. We present an approach for estimating the mass transfer coefficient (h , m/hr) of fumigant compounds across agricultural films (Fig. 3). The h is greatly dependent on the affinity of film material and fumigant.

Because agricultural films are sorptive for these fumigants, this method accounts for the adsorbed mass by the time lag before sorption equilibrium, and system kinetics after sorption equilibrium, under steady-state conditions. The mass transfer coefficient measured by this method depends on the film materials and temperature, and slightly film thickness in case of polyethylene, making this method useful for comparisons of film permeability under different management practices, application techniques, and environmental conditions. Since the method requires a minimum of equipment and is easy to employ, it will be useful as a screening tool in the development of new films and management practices for agricultural extension agents and fumigants.

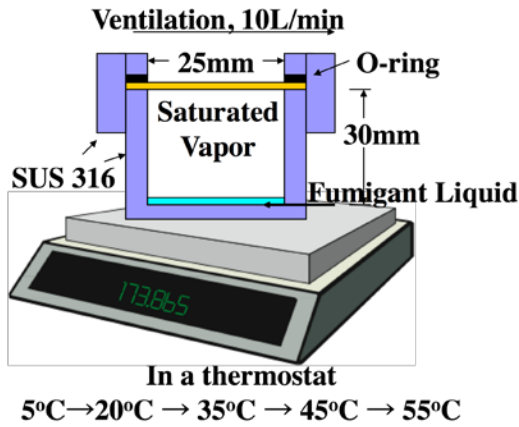


Fig. 1 Test method for determination of fumigants gas permeability rates through plastic films by the cup method

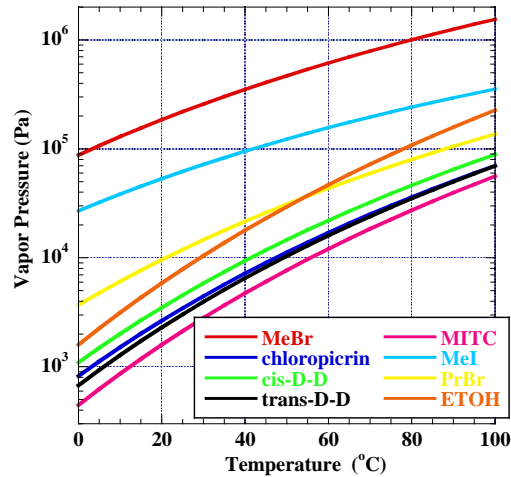


Fig. 2 Temperature dependence of vapor pressures of soil fumigants

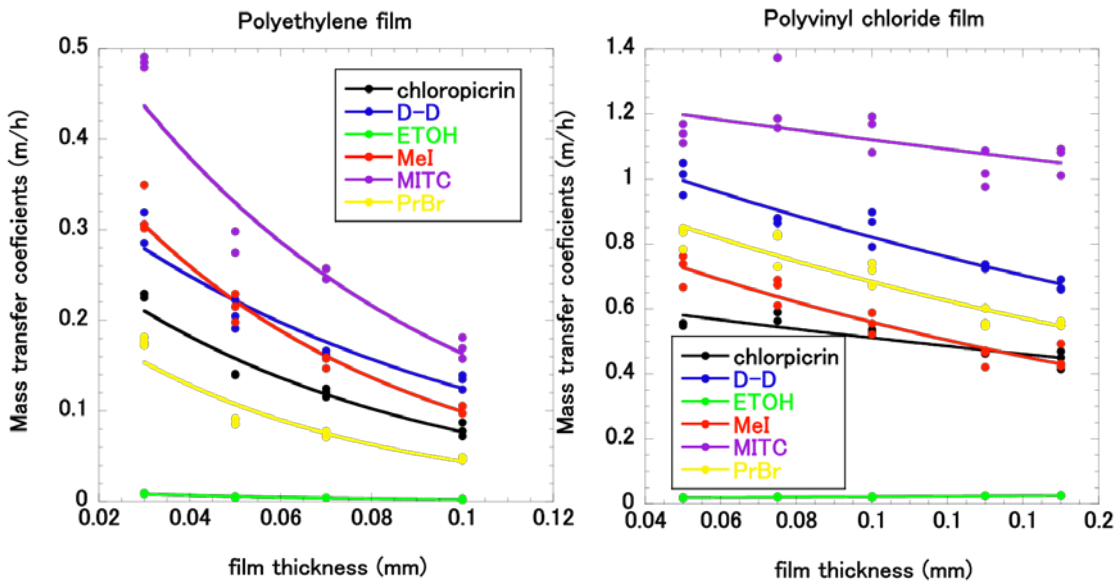


Fig.3 Mass transfer coefficients of soil fumigants through polyethylene and polyvinyl chloride films