

PLASTICIZER MIGRATION

INTRODUCTION

Flexible PVC or vinyl is a cured mixture of hard PVC resin, plasticizers that soften the resin and other additives, which provide processing and appearance values. The resin and the plasticizer are not chemically bound but held together by strong electro-motive forces as a solid solution. Thus, plasticizer, over a long period of time, is capable of being removed from the surface of the film. The migrated plasticizer is replaced by material from the vinyl mass. The mechanism by which plasticizer moves from the mass to the surface is called diffusion.

THE SCIENCE

The diffusion of plasticizer from vinyl and its absorption by other substrates is a well-studied and understood phenomenon. In most end use applications, it is generally accepted that diffusion follows Ficks law. In its simplest case, Ficks law can be derived to:

$$F = \frac{-D(C_1 - C_2)}{L} \quad D = D_0 e^{-E/RT}$$

F = Mass flow of plasticizer g/cm² - sec

D = Diffusion coefficient of plasticizer cm²/sec

C₁ = Concentration of plasticizer in the vinyl g/cm³

C₂ = Concentration of plasticizer in the contact g/cm³

L = Thickness of the coating cm

e, E, R = Constants

T = Temperature

We can then predict the amount of plasticizer that will migrate if we know the diffusion coefficient, the plasticizer concentrations, and the temperature.

PLASTICIZER EFFECT

The major class of chemical compounds used to plasticize vinyl are called esters. A large number of esters have been developed to provide special performance properties in vinyl products. Diffusion rate is one of the properties that control vinyl compound permanence.

The polarity, viscosity and molecular weight of the plasticizer affect the diffusion rate. Plasticizers with low diffusion rates can be chosen to minimize migration. Unfortunately, all other performance attributes that affect coated fabric and film performance are affected by the choice of plasticizer, and the manufacturer must balance all these property effects.

CONTACT SURFACE EFFECT

The diffusion of plasticizer out of the vinyl is not the only factor that determines the successful performance of a product. Others include the contact environment, be it air in film application, water in a sheet application, or a painted surface in an upholstered product. The effect of plasticizer on the contact surface must be considered in the optimum product design.

UPHOLSTERY

Vinyl coated fabrics have an historical record of softening or marring lacquered and painted surfaces after extended contact. The major cause of finish marring has been identified as the migration or diffusion of plasticizer from the vinyl product to the finish.

When flexible vinyl is placed in contact with a painted surface, the plasticizer can diffuse into the finish (because the plasticizer concentration C₂ is low). As it is absorbed or removed, plasticizer moves from the high concentration vinyl (C₁) to the surface where more can be absorbed by the finish. Diffusion occurs at a very slow rate, and it is well known that vinyl fabrics have a service life of over twenty years. Additionally, another factor must be considered in evaluating the plasticizer effect in finish mar.

We have assumed that the finish will absorb all the plasticizer delivered to it by the vinyl fabric. Historically, this was true since most finishes were based on air dry solvent systems with resin that could be plasticized by the same esters as used in the vinyl. Today, the development of water based, UV cured, and cross-linked technologies use resins that are much more resistant to absorption of ester plasticizers and are not softened by the low levels that will migrate.

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PLASTICIZER MIGRATION continued

Proper product design for maximum performance will require experimental investigation of both the vinyl fabric components and the surface finish. A sound understanding of both technologies can assure a successful performance of vinyl in upholstered furniture applications.

INDUSTRIAL SHEET AND FILM

Vinyl sheet and film is a versatile material that finds applications in numerous decorative and protective applications. Service conditions range from simple room temperature air and environments to harsh industrial service where high temperature and solvent contact must be considered.

As the equation implies, weight loss can be minimized by controlling the diffusion rate of the plasticizer through the proper choice of molecular weight and compatibility suited to the service atmosphere and temperature.

PRINTING EFFECTS

Plasticizer diffusion affects printing ink adhesion, both initially and in the long term. If a long period exists between film manufacture and decorating, a condition of high plasticizer surface concentration may develop that interferes with ink adhesion. Usually, a surface cleaning corrects that condition. Long-term ink adhesion or performance depends on the compatibility of the ink binder with the plasticizer. Many ink resins are compatible, but service testing should be done.

ADHESIVE SERVICE

Vinyl sheet and film is readily fabricated into products through simple thermal or adhesive bonding. Adhered product design considerations are the same as discussed above for ink. The chemistry of the adhesive must be matched to the vinyl plasticizer for cost and service optimization.

LIQUID CONTACT SERVICE

The ability of a vinyl product to perform well in liquid contact service is a complex issue to predict. Service life will be dependent on the miscibility of the plasticizer with the liquid and the solubility of the resin in the liquid.

When liquid penetrates the part (like petroleum distillates), the resin can swell and release plasticizer faster than the diffusion constant in air would predict. If the liquid does not penetrate the part (like water), plasticizer loss may be only slightly faster than the loss in air.

STAIN RESISTANCE

The ability of a vinyl part to resist stain can be better understood if stainant is viewed as liquid contact service. The degree of staining is dependent on the miscibility of the stainant and plasticizer. Permanent stain occurs when the stainant diffuses into the plasticizer below the resin surface.