Waters
Lab Highlights
An Internal Communication of Applications and Techniques
Volume 2, No. 5
POLYMERS
82.600.019.004.056

POLYVINYL CHLORIDES

CHEMISTRY

Polyvinyl chloride (PVC) is prepared via direct free radical polymerization with benzoyl peroxide initiation as shown:

$$n\ CH_2 = \underset{Cl}{CH} \xrightarrow[\text{Heat}]{\text{Benzoyl Peroxide}} \{CH_2\text{-}\underset{Cl}{CH}\}_n$$

In most cases the polymer obtained from this reaction is useless to the polymer processor unless certain additives are present. For this reason PVC is considered a compound rather than a plastic. The first type of additive is a primary plasticizer such as phthalates, adipates, trimellitates and some polyesters, the purpose of which is to increase the flow characteristics of the PVC and increase the overall properties of the polymer. Secondary plasticizers such as chlorinated hydrocarbons can also be used to aid in polymer processing. The secondary plasticizers are used bacause they are less expensive but, unfortunately, they will migrate out after a certain time period. Stabilizers such as Ba-Cd-Zn metal soaps, organophosphites and organotins are used to increase the stability of the polymer both in processing and in use. The most popular stabilizer is a combination of the Ba-Cd-Zn metal soaps with epoxide soybean oil (ESO), which increases stability threefold due to synergistic effects. Other additives include emulsifiers (polyethylene glycol), thickeners (Cab-O-Sil™ Silica), fillers ($CaCO_3$; 10-50%) and pigments to color the compound. PVC is used for wire cable, furniture, handle coverings for tools, shoes and boots, and myriad other applications.

CHROMATOGRAPHY

Figure #1 (reverse side) is the analysis of a PVC sample via gel permeation chromatography. Region A is the molecular weight distribution of the PVC sample. Obtaining the molecular weight distribution of a PVC is important because the chemist can determine the amount of an additive that should be added to increase polymer lifetime and processibility from calculation of the molecular weight averages. For example, if the viscosity average molecular weight ($\bar{M}_v$) is greater for a new batch of PVC resin the chemist may add a larger amount of DOP to improve extrudability and thus decrease waste caused by improper processing conditions. The additives which elute in Region B include a primary plasticizer (di-2-ethylhexyl phthalate, DOP), a secondary plasticizer (chlorinated hydrocarbon) and an ESO stabilizer. Further analysis of the compound on columns optimized for the low molecular weight additive region is shown in Figure #2. Analysis of the additive region allows the chemist to monitor the additives to insure that the correct quantities are present in the polymer and that these amounts are properly dispersed throughout the polymer.

See reverse side for Figures 1 and 2.

FIGURE 1
POLYMER ANALYSIS

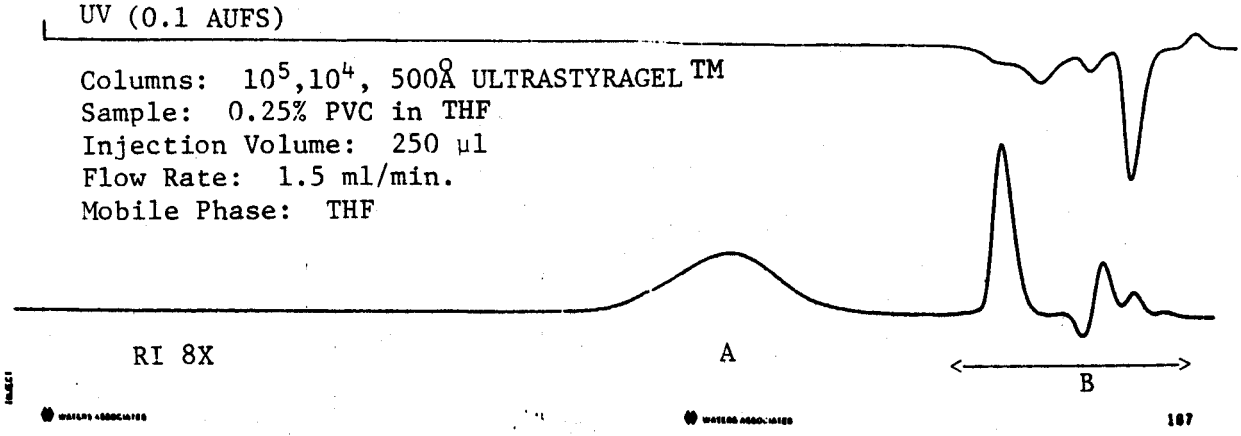
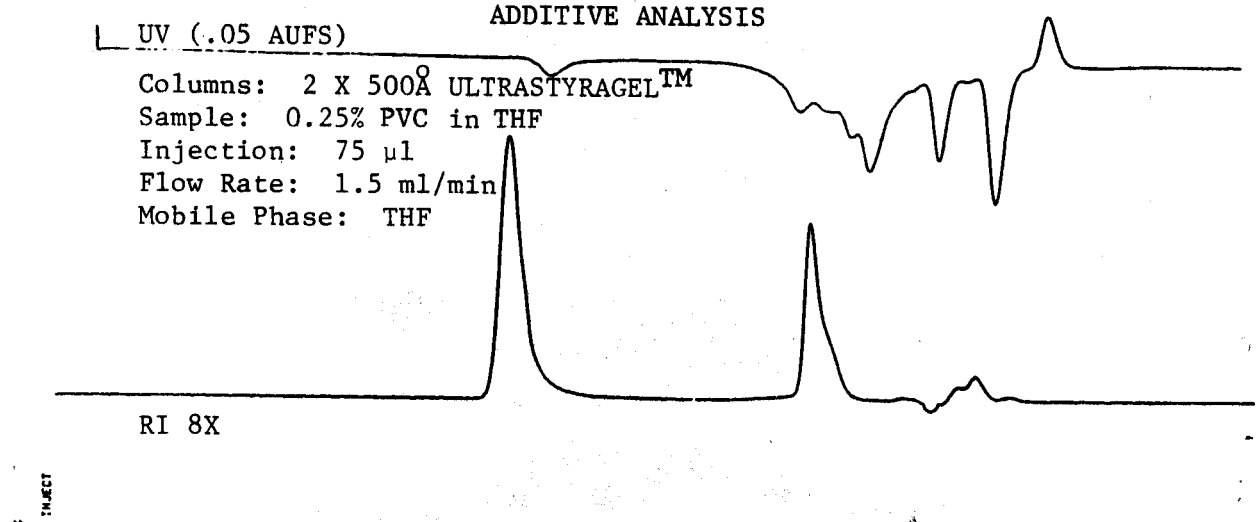


FIGURE 2
ADDITIVE ANALYSIS



WATERS ASSOCIATES
Mark Andrews