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Stabilization of Polyvinyl Chloride by Some Conducting Polymers

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Polyvinyl chloride (PVC) is one of the four major commercial polymers used widely for both domestic and industrial purposes. It is a low cost – high volume synthetic polymer used in home construction, electrical insulation, and for various other purposes. In 2000, over one billion pounds of PVC were produced. The primary drawback of the polymer is its instability at temperatures above 60°C and when exposed to ultraviolet radiation. As a result of degradation, PVC releases toxic hydrogen chloride (HCl) gas, which is primarily responsible for death in household fires. Destabilization causes substantial damage to the material and loss of its many useful physical and chemical properties. The purpose of stabilization, therefore, is to maintain the original characteristics of the polymer and to ensure its desired service life.

Various inorganic and organic chemicals, such as barium stearate, calcium stearate, barium carboxylate, etc. have been used to improve the stability of PVC (Ivan, 1996). These compounds act as arrestive stabilizers by removing, neutralizing, or inactivating various potential degradation sources that accumulate in the polymer. It has been observed in our laboratory that lignosulfonic acid-doped polyaniline (LP) is capable of stabilizing PVC when blended at a low percent composition. LP is a conducting polymer with anti-static and anti-corrosion properties with significant dispersibility in water as compared to HCl doped polyaniline (HCl-PANI) (Berry and Viswanathan, 2001). The structure of the polymer in its emeraldine salt (ES) form is shown in Figure 1. It's dispersibility in water is enhanced due to the doping of polyaniline with lignosulfonic acid, a highly water-soluble compound.

Studies were conducted by mixing LP with PVC at 5%,

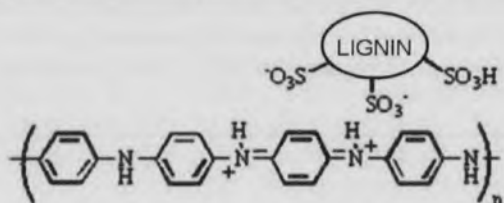


Fig. 1. Structure of LP in the Emeraldine Salt (ES) form.

10%, 20% and 30% (by mass of LP : PVC). Five grams of finely powdered untreated (unstabilized) PVC was poured into 100 mL distilled water in a beaker under constant stirring to produce a suspension. A measured amount of LP

(as a moist cake and in the ES form) was added to the suspension, and the stirring was continued for one hour to adequately disperse the LP. It was then filtered with No. 42 Whatman filter paper, followed by vacuum drying at room temperature to assure complete removal of moisture. The mixtures were heated to 200°C in an oil bath, and the released HCl gas was collected in 10.0 mL of a standardized 0.1000 M NaOH solution, which was then back titrated with a standardized 0.1000 M hydrochloric acid solution to determine the loss of HCl from PVC. An untreated sample of PVC (containing exactly the same amount of PVC as was present in the PVC : LP composite) was heated side by side in the same oil bath to compare the amount of HCl gas released in order to determine the degree of stabilization by LP. The untreated sample was tested as received. Each composite was studied in triplicate to determine the reproducibility of the results. Similar studies were conducted by mixing HCl-PANI with PVC to compare the stabilization efficiency of HCl -PANI and LP.

The results of the stabilization studies are shown in Table 1, where the observed molarity of NaOH is shown as a function of % weight LP in the composites. If LP acts as a stabilizer, the composite upon heating would release less HCl gas than the PVC alone. Consequently, less NaOH will be consumed. A titration with the standardized hydrochloric acid, therefore, would reveal a smaller change in the concentration of NaOH. Obviously, the PVC:LP composite containing 5 - 20% LP showed a smaller decrease in concentration of NaOH. Therefore, LP does act as a stabilizer. One notices, however, that the absolute change in concentration varied slightly on a day-to-day basis for the same amount of PVC used in comparing the results of various composites. For example, the same amount of PVC used in conjunction with 5% and 10% composites showed an average molarity of 0.06987 M and 0.07282 M NaOH respectively, a difference of about 4%. The reproducibility of each composite measurement performed in triplicate, however, was within 0.5%.

Because of the variations as described above, it was considered more appropriate to plot the difference in molarity of NaOH (molarity of NaOH for PVC : LP composite vs. molarity of NaOH for PVC alone) as a function of weight percent stabilizer. As a result, the effect of day to day variation was minimized. The results are shown in Figure 2. The difference in molarity was found to be maximum for the 5% LP composite, indicating that maximum stabilization occurs with this composite. With

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Table 1: Stabilization of PVC by LP. Released HCl gas from PVC was absorbed in 0.1000M NaOH Solution. The Molarity of the remaining NaOH for each PVC : LP composite with relative standard deviation of measurements in triplicate is reported.

No. of Experiments	PVC (200 °C)	% of LP in PVC	PVC + LP (200 °C)
1	0.0755 ±0.0034	5	0.0903 ±0.0020
2	0.0747 ±0.0025	10	0.0880 ±0.0021
3	0.0772 ±0.0015	20	0.0870 ±0.0005
4	0.0782 ±0.0025	30	0.0717 ±0.0017

increasing percentage of LP in the composite, the stability decreases. It is, therefore, concluded that about 5% PVC: LP composite gives the best stability. We plan to study still lower composite percentages (1% through 4%) to precisely determine the LP composite with maximum stability. In order to assess the effect of HCl-PANI (which is also a conducting polymer) on PVC stability, similar data for HCl-PANI : PVC composites are also plotted in Figure 2. One notices that the stability increases as the percentage of HCl-PANI in the composite is increased, but the effect is not as significant as with LP. Clearly, doping with lignosulfonic acid has a profound effect on the stabilization of PVC. The mechanism by which LP acts as a stabilizer is being further investigated in our laboratory. Also, the structural changes that occur in PVC during degradation and stabilization are also being studied by ultraviolet and infrared spectroscopy as well as by thermogravimetric analysis.

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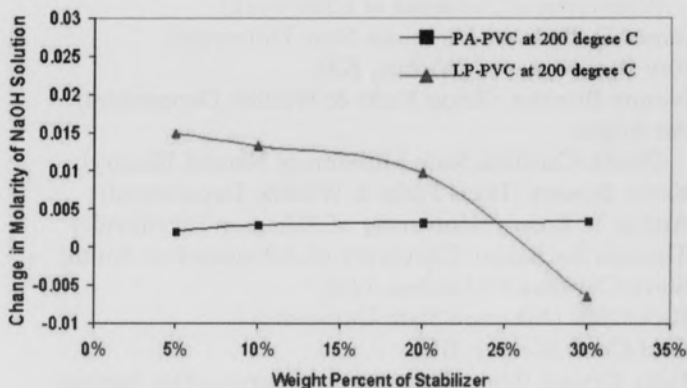


Fig. 2. The SIT fully pinched-off