Article Number: B121D89

A Paper presented at the 39th CSN Annual International Conference, Workshop and Exhibition, Rivers State University of Science and Technology, Port Harcourt, Nigeria.
18th – 23rd September 2016



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# Studies on the molar ratios of optimal interactions of NR-PVC blend using IR spectroscopy

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**Blends of Natural Rubber (NR) and poly (vinyl chloride) (PVC) were made by the liquid-liquid technique. The analytical study was carried out by the means of Infra- Red spectroscopy. The aim of the research is to locate blend compositions of optimal interaction, between the components. Using frequency method the functional groups of optimal interactions were; C-Cl, C=C, and $CH_3$. The result obtained for establishing the base mole ratio of optimal interaction by means of frequency average deviation for the polymer pair was 0.395. It was noted from this study that there was interaction between the polymer pair and points of the degrees of the polymer pair interactions were indicated.**

**Key words:** Blend, poly (vinyl chloride) (PVC), natural rubber (NR), molar ratios, Fourier-transform infrared spectroscopy (FTIR).

## INTRODUCTION

Polymer blends, by definition, are physical mixtures of structurally different homopolymers or copolymers (Santos and Gutherie, 2006). By 1976 blending was being extensively carried out with a wider range of polymers, though the earliest significant use of blends as plastic material dates from the late 1940's (Onuegbu et al., 2008). Polymer blending provides a powerful route to engineering new properties in materials using available polymers. By this technique it is possible to produce a range of materials with properties that are superior to that of each individual component polymers (Khan et al., 2008). That is, from an industrial point of view, polymer blends fill the deficiency in price/performance of existing homopolymers with a relatively minor capital investment. A shorter period of time and effort is required to develop a new product via blending existing materials in comparison with that needed to develop a new polymer (Miles and Rostani, 1992). Techniques in resin blending are simple and efficient method for improving the properties of polymers, and have been used widely in polymer modification field (Liu et al., 2008). Blending methods usually involve solid - to - liquid, solid - to -solid or liquid - to - liquid mixing (Eboatu et al., 1990). As an important type of polymer material, rubber is widely used due to its high and reversible deformability. Since the essential modulus and strength of neat rubber are low, an additional reinforcing phase is necessary for the practical uses of rubber materials (Sui et al., 2008).

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**Table 1.** Volume ratio of the different blends.

| Polymer | Solvent | Volumes of the blended solutions (ml) | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NR | Toluene | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 | 10.0 |
| PVC | THF | 0.0 | 1.0 | 2.0 | 5.0 | 7.0 | 0.0 | 5.0 |

**Table 2.** Base mole ratios of the blends.

| Polymer | Solvents | Base Mole Ratios | | | | | | |
|---|---|---|---|---|---|---|---|---|
| NR | Toluene | 1.00 | 0.605 | 0.480 | 0.234 | 0.179 | 0.133 | 0.093 |
| PVC | THF | 0.00 | 0.395 | 0.566 | 0.766 | 0.821 | 0.867 | 0.907 |

According to Hafezi et al. (2007) blending plastic and rubber helps to improve the physical, thermal, and mechanical properties as well as to modify the processing characteristics and cost reduction of the final product. To this effect this study seeks to find out the molar ratios of optimal interaction of natural rubber- poly (vinyl chloride) (NR-PVC), components of the blend.

## EXPERIMENTAL

### Chemicals

THF (Tetra hydro furan) is Qualikems make. Toluene solvent is BDH make, procured from the Bridge-Head, Onitsha. NR crepe, obtained from the Rubber Research Institute, Iyalamo, Benin, Nigeria, while PVC resins, which has the temperature of melting, 88°C, was obtained from LG Chemical Ltd, Korea.

### Blend preparation and Analysis

2.0 g NR crepe was dissolved in 200 ml Toluene solvent while 6.0 g of PVC resin was dissolved in 100 ml THF solvent, after which the two were blended together in different proportions are shown in Table 1. The solution mixtures were then poured on glass petri-dishes to produce thin films by evaporation. FTIR of these thin films were obtained using the Model_Shimadzu FTIR 84005, after which seven results were obtained. The NR homopolymer, which was not mixed with the PVC solution was used as the control; from which the frequency, absorbance, and energy deviation tables were deduced, as compared with others (the different blends) (Table 2).The base mole ratios of each homopolymer, and the different blends were calculated using the formulae:

$$\text{NR base mole} = \frac{\text{Weight of NR polymer}}{\text{Base molar mass of NR}}$$

$$\text{NR base mole fraction (BMF)} = \frac{\text{NR base mole}}{\text{NR base mole + PVC base mole}}$$

$$\text{PVC base mole fraction (BMF)} = \frac{\text{PVC base mole}}{\text{NR base mole + PVC base mole}}$$

## RESULTS AND DISCUSSION

### Studies using IR spectroscopy

When two or more polymers interact, there is perturbation and the vibration frequencies of these polymers shift from their normal frequencies. The vibrational spectrum of a molecule is considered to be a unique physical property and is characteristic of the molecule. As such, the infrared spectrum can be used as a fingerprint for identification by the comparison of the spectrum from an "unknown" with previously recorded reference spectra. Also it is possible to deduce whether specific functional groups are present. If detected, one is also able to determine local orientation of the group and its local environment and/or location in the structure (Coates, 2000).

### Tables and Graphs

Based on the spectra obtained from the FTIR, the difference in volumes between pure NR and the different NR- PVC mixtures (as seen in Table 2) were calculated and tabulated. This is based only on the frequency of interaction of the spectra. Using Table 3, a graph was plotted (Figure 1), which indicates the points where the NR-PVC mixtures interacted. Using the correlation table data, the functional groups responsible for such interactions were detected. From Figure 1, the functional group of optimal interaction of NR: PVC blend are C-Cl, C=C, and $CH_3$ with peak numbers 0-1, 2-3 and 7-8, which have 608.56, 836.17-693.43, and 1428.34-1329.96, frequencies, respectively. The vibrations may have shifted the frequencies from 1680-1600 of alkenes to 836.17 $cm^{-1}$.This could be as a result of the electron withdrawing Cl attached to the PVC carbon or the double bond present in the poly isoprene of the Natural Rubber molecule (Table 4). From Figure 2 the highest point of interaction is at 0.395 base mole fractions. This means that at this point there is the highest level of miscibility and bonding of the participating polymers.

**Table 3.** Establishing the functional group of optimal interaction of NR: PVC blend using frequency.

| Peak Numbers | Frequency Change (? F) | | | | | |
|---|---|---|---|---|---|---|
| | C1 | C2 | C3 | C4 | C5 | C6 |
| 1 | 148.52 | 78.12 | 80.05 | 1.93 | 25.08 | 160.1 |
| 2 | 4.82 | 142.74 | 144.67 | 0.96 | 1.93 | 57.86 |
| 3 | 94.52 | 100.31 | 126.34 | 0.00 | 2.89 | 141.77 |
| 4 | 124.41 | 129.90 | 132.13 | 0.97 | 2.90 | 226.64 |
| 5 | 132.12 | 152.39 | 155.28 | 0.96 | 2.89 | 260.39 |
| 6 | 219.89 | 67.51 | 69.44 | 0.96 | 16.40 | 298.01 |
| 7 | 238.21 | 106.09 | 102.23 | 0.96 | 5.78 | 232.43 |
| 8 | 301.87 | 231.46 | 233.39 | 0.00 | 8.68 | 171.77 |
| 9 | 412.78 | 1259.56 | 73.30 | 0.97 | 3.86 | 331.77 |
| 10 | 407.96 | | 1183.36 | 991.44 | 2.90 | 305.73 |
| 11 | 901.75 | | | 649.07 | 454.25 | 613.38 |
| 12 | 1111.99 | | | 740.69 | 361.67 | 401.121 |
| 13 | 1065.71 | | | | 569.98 | |
| 14 | 183.25 | | | | | |
| 15 | 379.03 | | | | | |

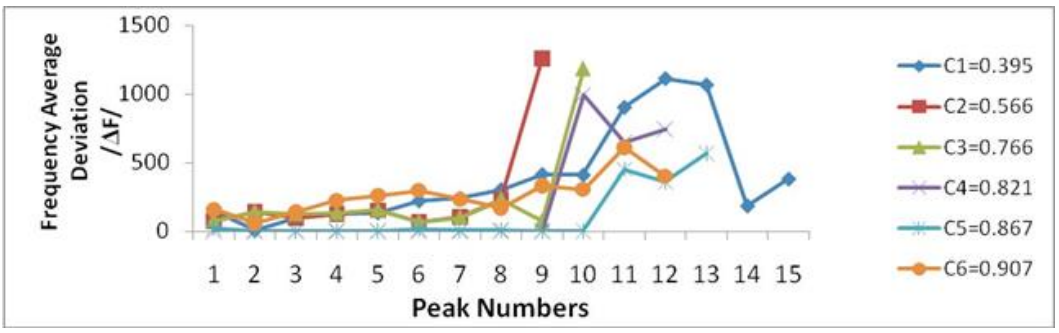


**Figure 1.** The functional group of optimal interaction of NR: PVC blend by means of Frequency. C1, C2, C3, C4, C5, C6, are base mole fractions PVC of one homopolymer.

**Table 4.** The base mole ratio of optimal interaction of NR: PVC blends using Frequency average deviation.

| PVC base mole fractions | 0.395 | 0.566 | 0.766 | 0.821 | 0.867 | 0.907 |
|---|---|---|---|---|---|---|
| Frequency Average Deviation | 381.789 | 252.009 | 230.019 | 199.076 | 112.25 | 266.739 |

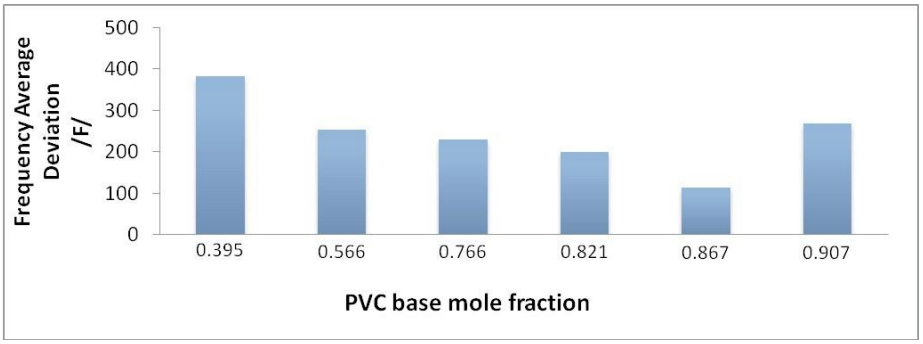


**Figure 2.** The base-mole ratio of optimal interaction of NR: PVC.

## Conclusions

The polymers used in this work are NR (hydrocarbon) and PVC (halogen containing polymer). It was noted from this study that there was interaction between the polymer pair, and points of interactions and the functional groups responsible for them were established. This, of course, will aid polymer chemists in knowing at what points to get NR-PVC blends of optimal interaction.

## CONFLICT OF INTERESTS

The authors have not declared any conflict of interests.

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