CHAPTER IV

RESULTS AND DISCUSSIONS

4.1. Mechanical Tests

4.1.1 Tensile Strength

The Fig 4.1 is a plot between the tensile strength and the NBR content.

An addition of NBR to plasticized PVC results in a decrease in the tensile strength. This is due to the flexibility and the softness of the NBR which is present in the plasticized PVC. For plasticized PVC with increasing NBR content, the resultant tensile strength was found to decrease.

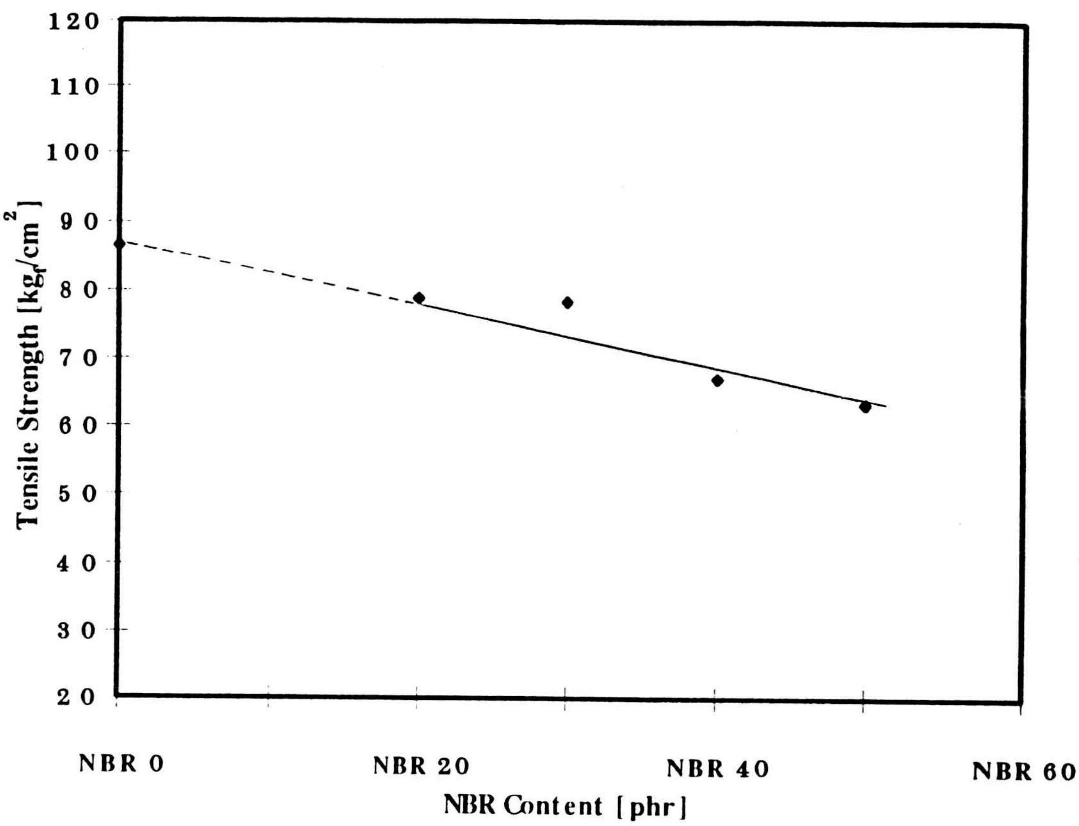

Fig 4.1: The relationship between the tensile strength and the amount of NBR in plasticized PVC.

4.1.2 Elongation at Break

The Fig 4.2 is the plot between the elongation at break and the NBR content.

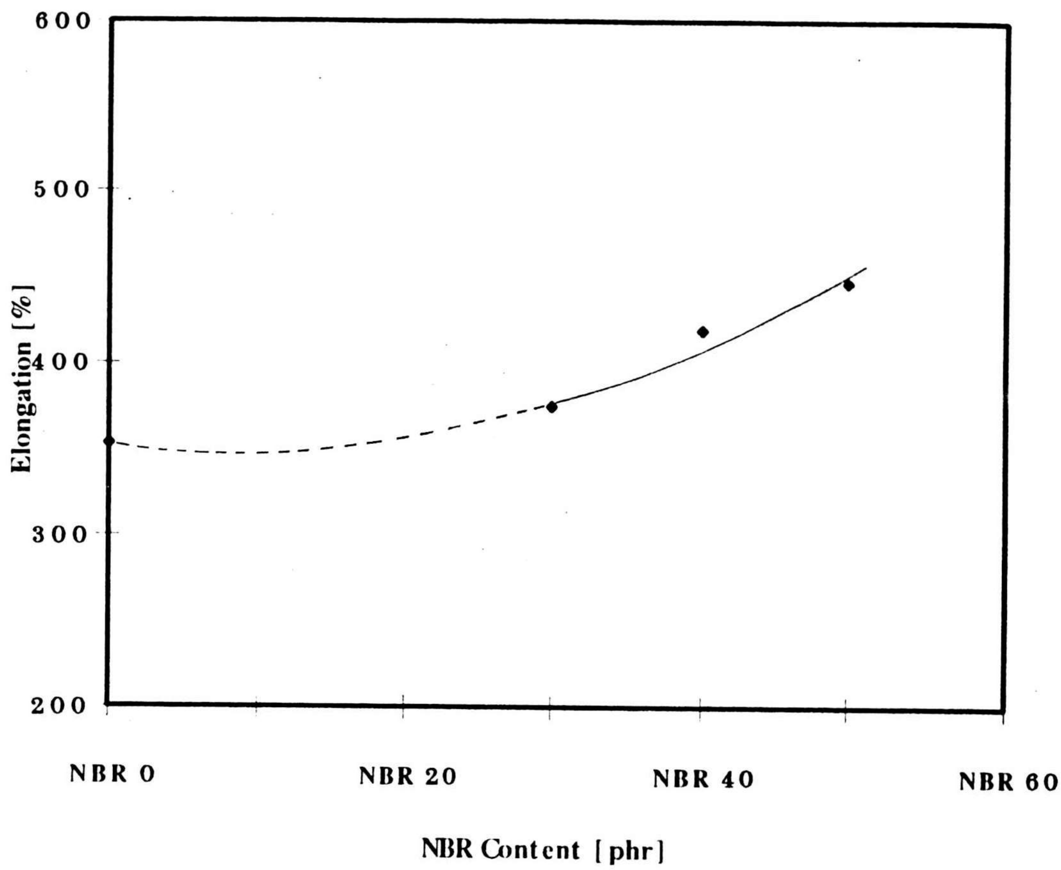

Fig 4.2: The relationship between the elongation at break and the amount of NBR in plasticized PVC.

Although the elongation at break seems to decrease slightly at 20 phr NBR content, the general trend is that the percentage of elongation at break increases with the NBR content beyond 20 phr. The enhancement in the elongation at break is a result of the elastic property of the NBR in the plasticized PVC.

4.1.3 Modulus

Fig 4.3 is the plot between the moduli and the NBR content in plasticized PVC.

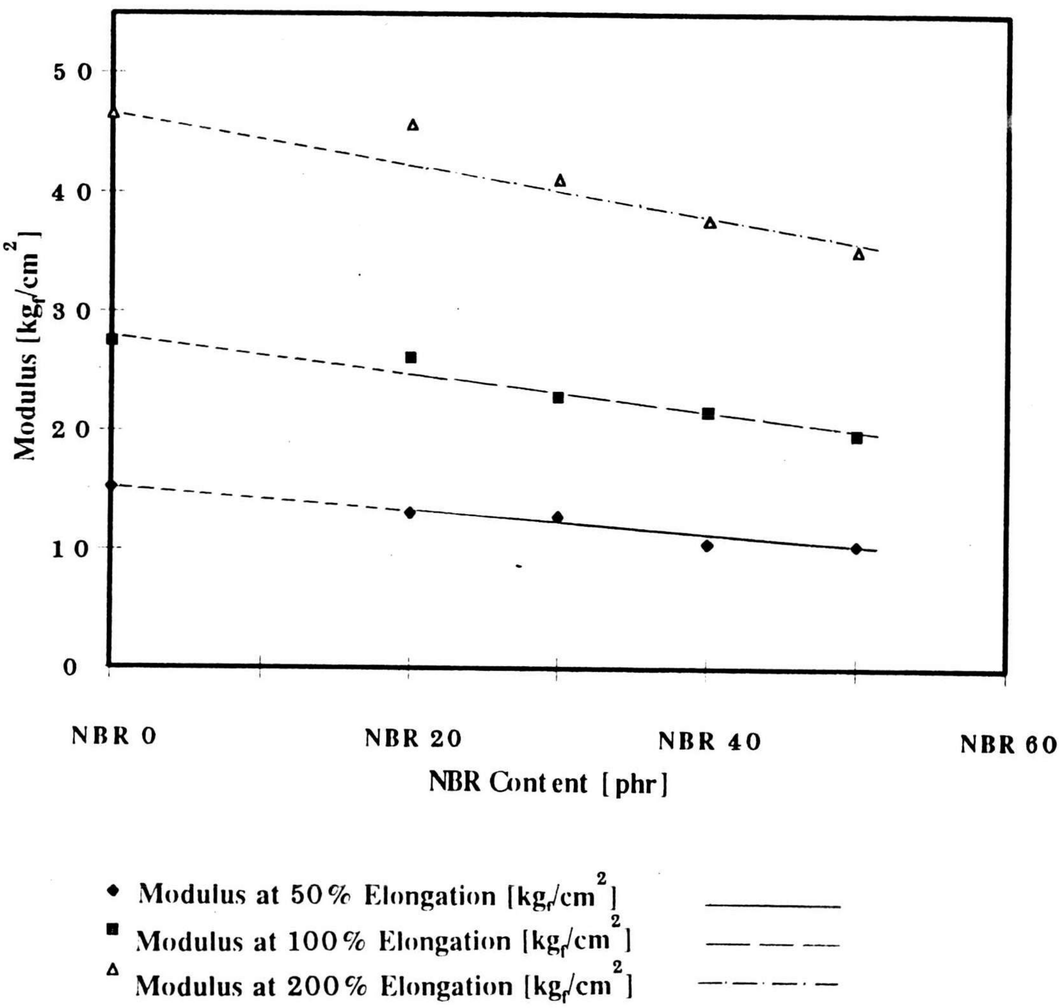

Fig 4.3: The relationship between the moduli and the amount of NBR in plasticized PVC.

All of the moduli, i.e. the modulus at 50%, 100% and 200% elongation decrease with the amount of NBR. Here again, the decrease is a result of the softness and low modulus imparted by the soft butadiene part in the NBR. Hence, plasticized PVC which contains NBR can easily elongate even under a relatively small load. Such PVC is likely to exhibit large deformation when it is stressed. The more NBR content there is in the plasticized PVC, the greater the change in the modulus towards that of rubber.

4.1.4 Tear Strength

Fig 4.4 is the plot between the tear resistance and the NBR content.

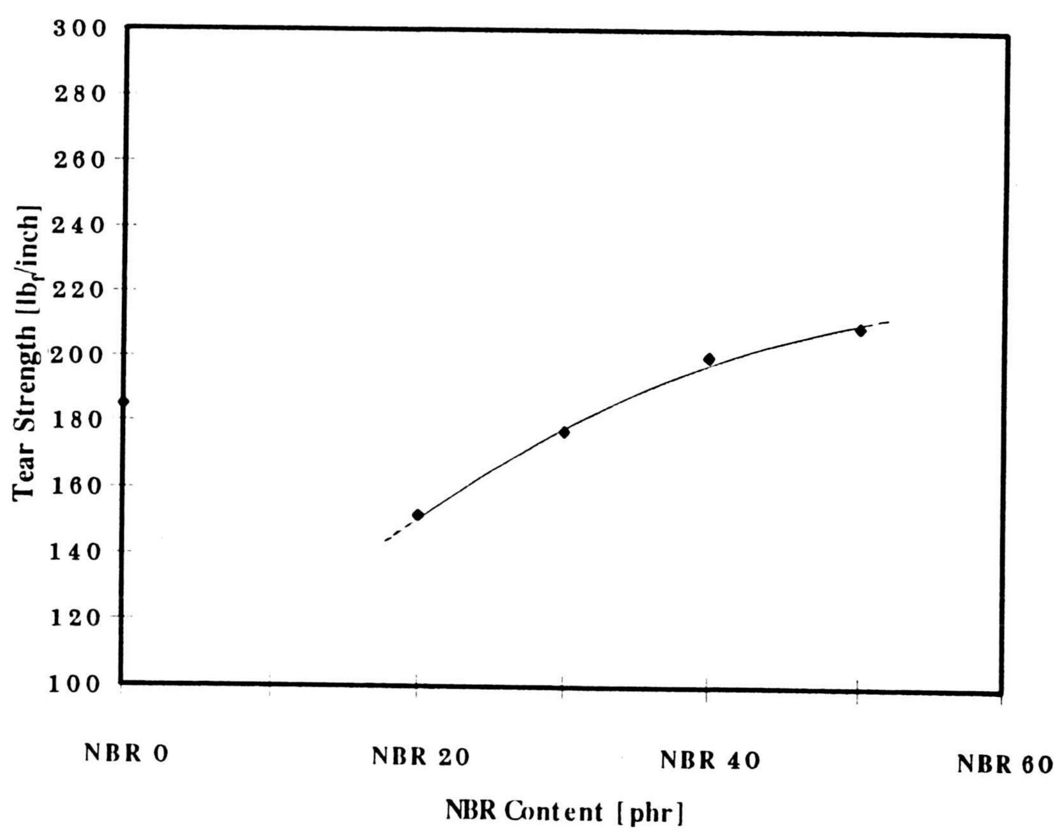

Fig 4.4: The relationship between the tear strength [Die C] and the amount of NBR in plasticized PVC.

The tear resistance decreases drastically from 185.3 lb_f/inch when there is no NBR to 151.9 lb_f/inch when the addition of NBR in plasticized PVC is 20 phr. However, the tear strength becomes greater as the NBR content is increased to 40 and 50 phr. The greater toughness is imparted by the NBR.

4.1.5 Compression Set

Fig 4.5 illustrates the effect of NBR to compressive behaviour of plasticized PVC.

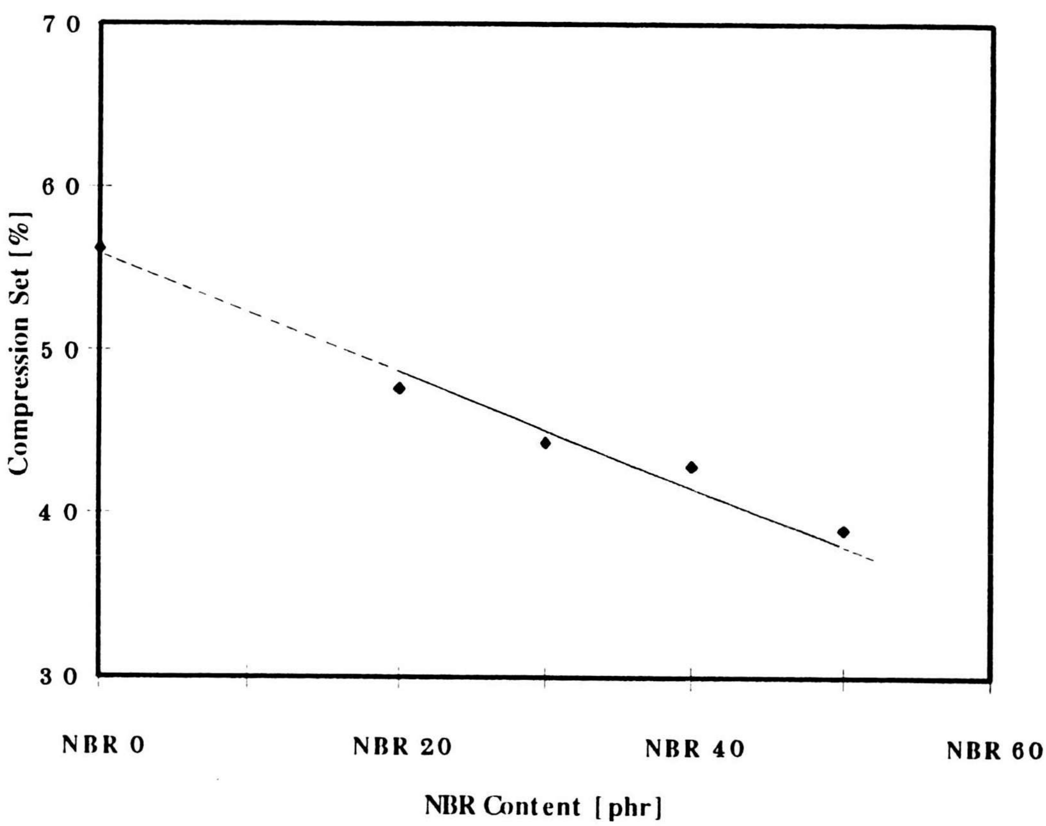

Fig 4.5: The relationship between the compression set and the amount of NBR in plasticized PVC.

The addition of NBR to plasticized PVC improves the compression property which is indicated by the decrease in the percentage compression set due to the enhanced flexibility of the NBR. The results indicate that the added NBR improves the retention properties after prolonged compressive stresses.

Thermoplastic polymers and especially plasticized PVC compounds show poor compression set values when compared to vulcanized elastomers. The differences become even greater when tests are carried out at elevated temperature due to the thermoplastic nature of these polymers. The thermoplasticity makes normal plasticized PVC compounds unsuitable for applications where low set under pressure is required such as window gaskets. The addition of elastomeric NBR to plasticized PVC compound gives a substantial improvement in the set properties, allowing the compound to be used in applications where these properties are important. The improvement of abrasion resistance implies the possibility of using NBR in plasticized PVC in shoe soles.

4.2 Physical Properties

4.2.1 Hardness

Fig 4.6 is a plot between the hardness and the amount of NBR in plasticized PVC.

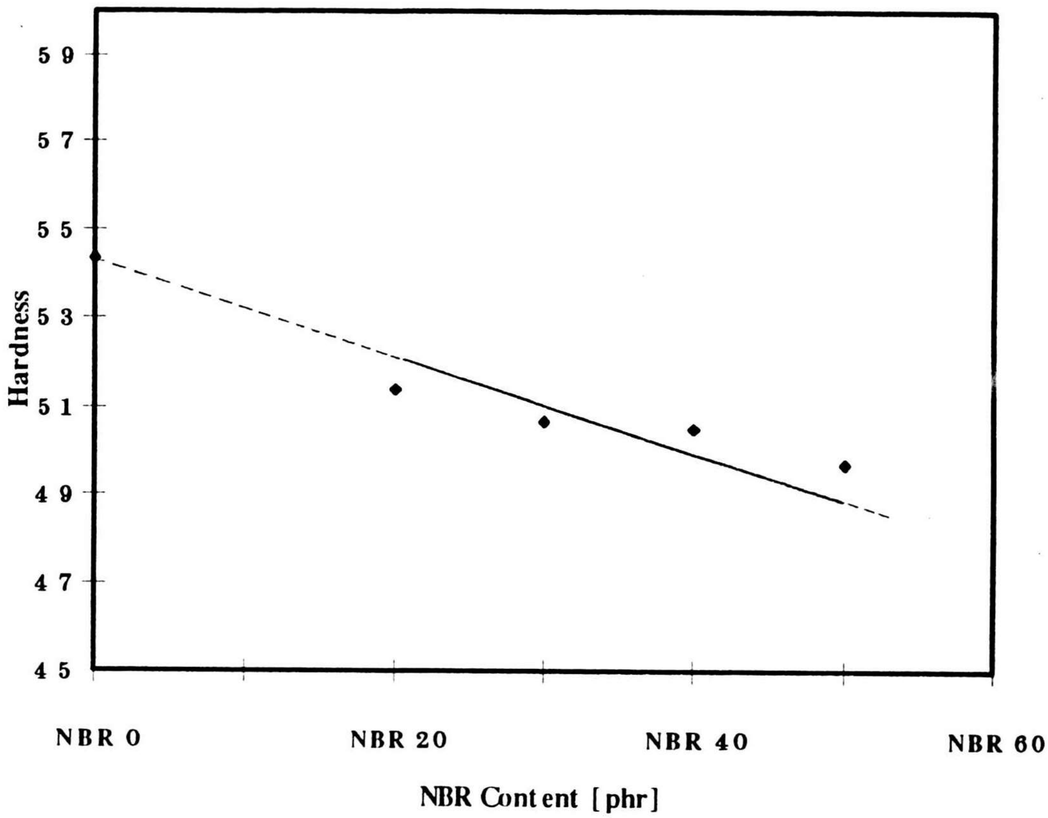

Fig 4.6: The relationship between hardness [shore A] and the amount of NBR in plasticized PVC.

The addition of NBR to plasticized PVC significantly reduces the hardness of plasticized PVC from, 54.32 to 51.40. This is because the nature of the NBR is quite soft. With the increasing NBR content from 20 to 50 phr, the resultant hardness was found to decrease slightly. The result implies that NBR can be utilized as a polymeric plasticizer. It can be applied together with some other monomeric plasticizers generally used in plasticized PVC.

4.2.2 Specific Gravity

Fig 4.7 is a plot between the specific gravity and the NBR content.

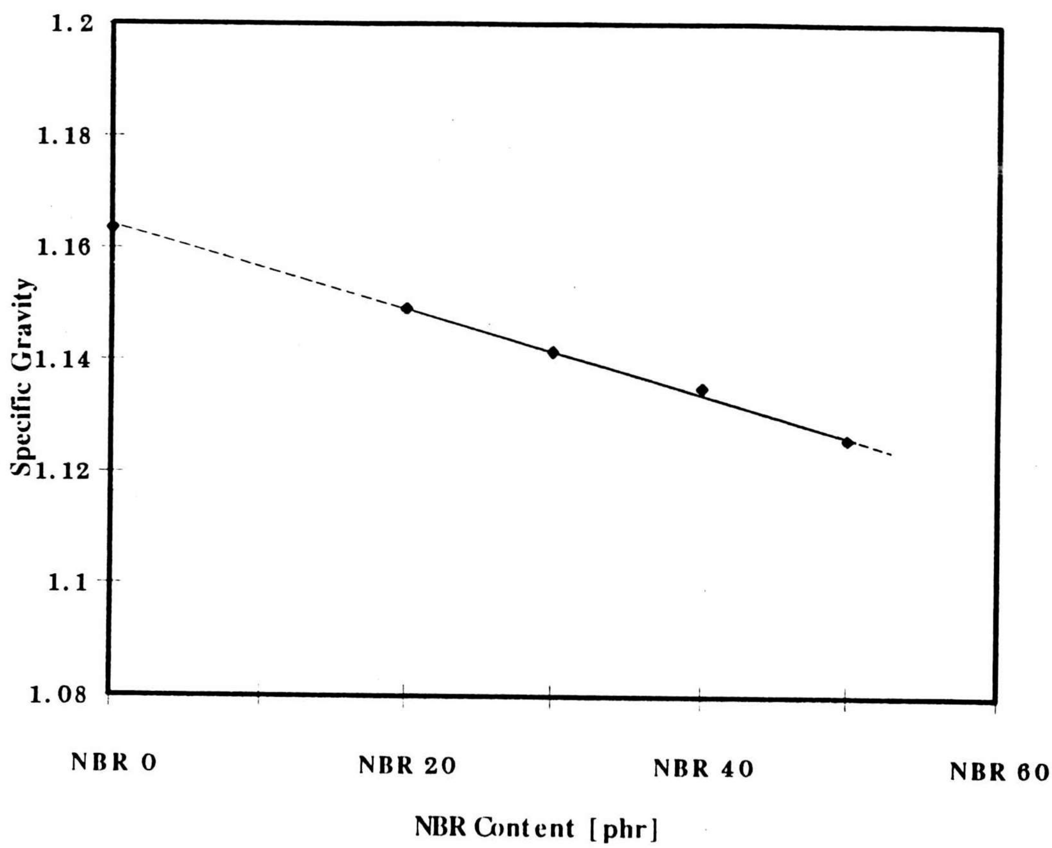

Fig 4.7: The relationship between the specific gravity and the amount of NBR in plasticized PVC.

The addition of NBR in plasticized PVC significantly reduces the specific gravity of the plasticized PVC. The specific gravity of NBR is 0.98. This is quite low when it is compared with that of the plasticized PVC which is about 1.16 for the plasticized PVC used in the present study. Thus, a higher content of NBR can lead to a lower specific gravity of the polymer mixture.

4.2.3 Color Property

Fig 4.8 shows the increase in the yellow index and the level of the NBR content.

This is the result imparted by the inherent color of NBR particles which is of light yellow shade. As a consequence, the addition of NBR to plasticized PVC results in a more yellow compound than that of the original plasticized PVC.

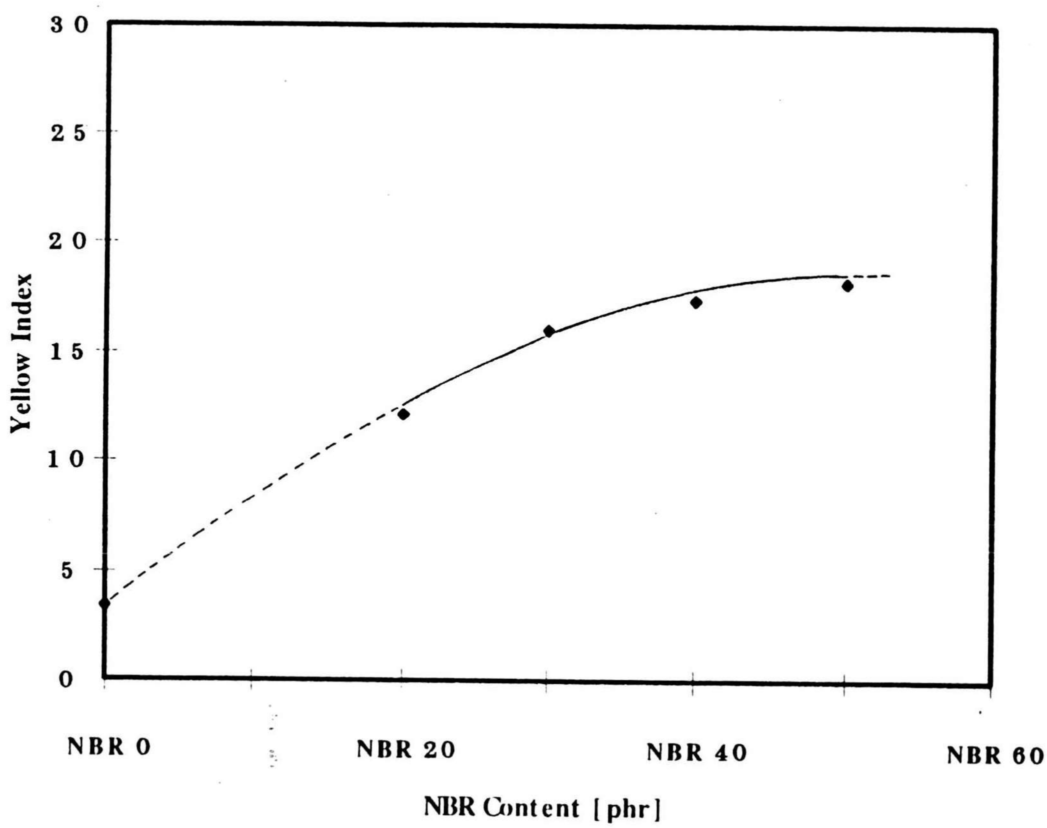

Fig 4.8: The relationship between the yellow index and the amount of NBR in plasticized PVC.

4.2.4 Abrasion Resistance

Fig 4.9 is the plot of the abrasion resistance against the NBR content.

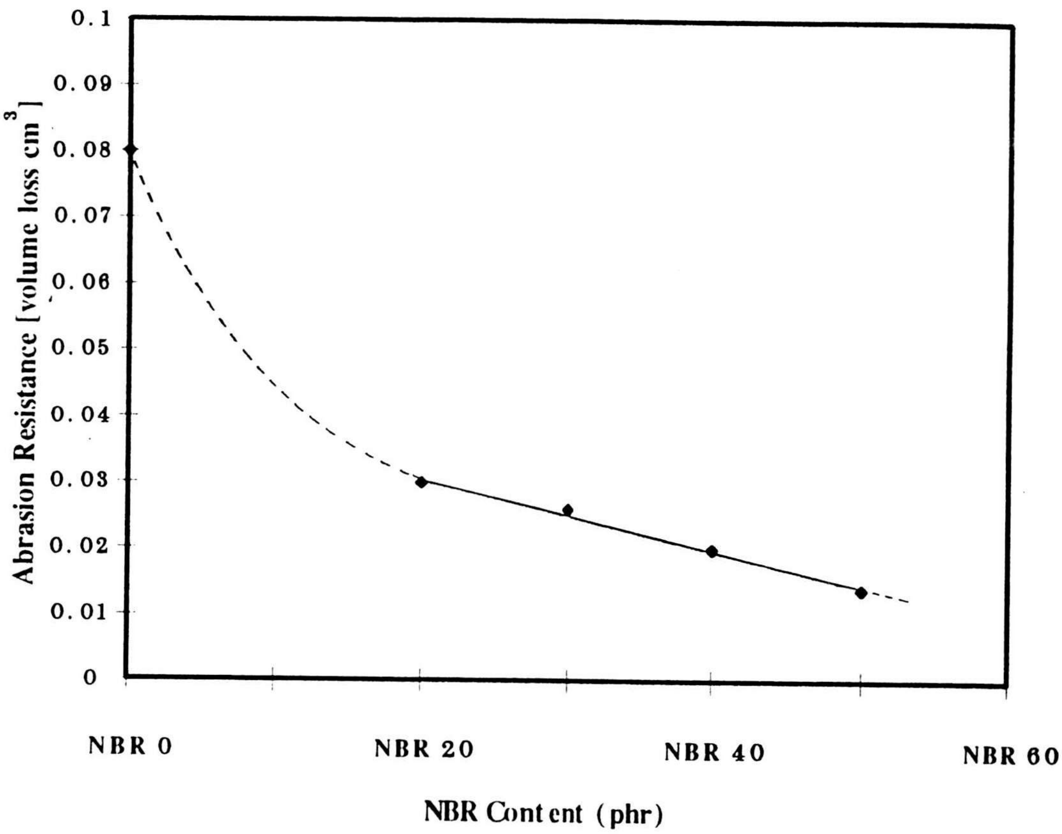

Fig 4.9: The relationship between the abrasion resistance and the amount of NBR in plasticized PVC.

The abrasion resistance was measured as the volume of material loss when the specimen was pressed against abrasive paper on a revolving drum. The resistance to abrasion was found to improve progressively with the content of NBR in plasticized PVC. The addition of NBR to plasticized PVC by 20 phr strongly decreases the volume loss of the abrasion resistance test from 0.080 cm^3 to 0.030 cm^3. When the NBR content in the plasticized PVC increase to 30, 40 and 50 phr respectively, the resistance to abrasion continues to increase despite their descending hardness. Possible explaination is due to the increase in the toughness of the polymer mixing induced by the NBR content. The enhanced elastic property means that less material is likely to be polished off the polymer surface when it was pressed against the abrasive paper.

The abrasion resistance of the plasticized PVC is poor and thus limits its use in footwear application. Hence, an addition of NBR to the plasticized PVC formulation opens a new way to improve the abrasion resistance. This is due to the elastomeric nature and the chemical structure of NBR.

4.3 Thermal Properties

4.3.1 DSC

DSC7 was used to study the compatibility between NBR and the plasticized PVC in the present study. The DSC thermograms of NBR, plasticized PVC without and with increasing amount of NBR content are shown in Figs 4.10 to 4.15.

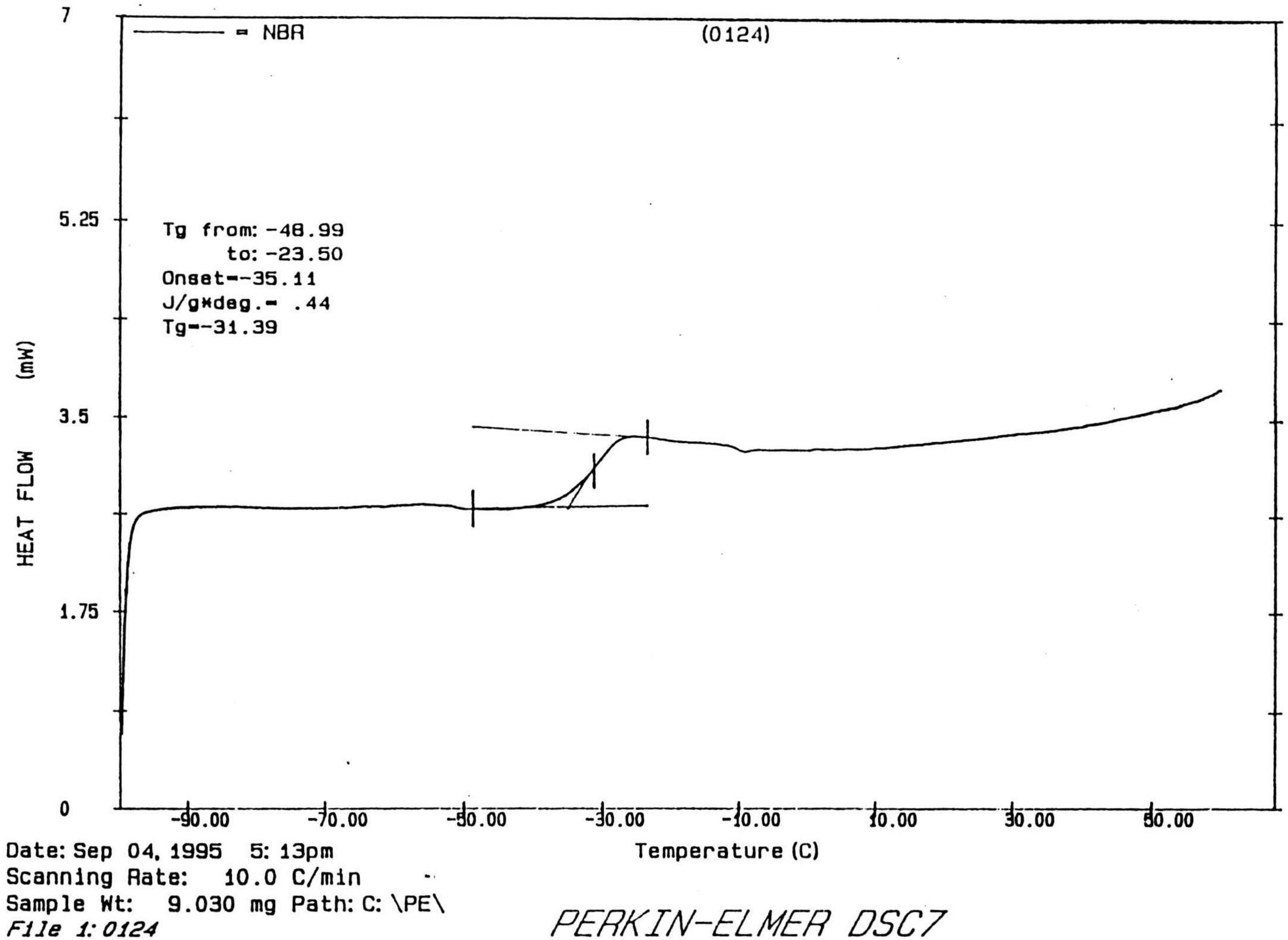

Fig 4.10: DSC thermogram of NBR,

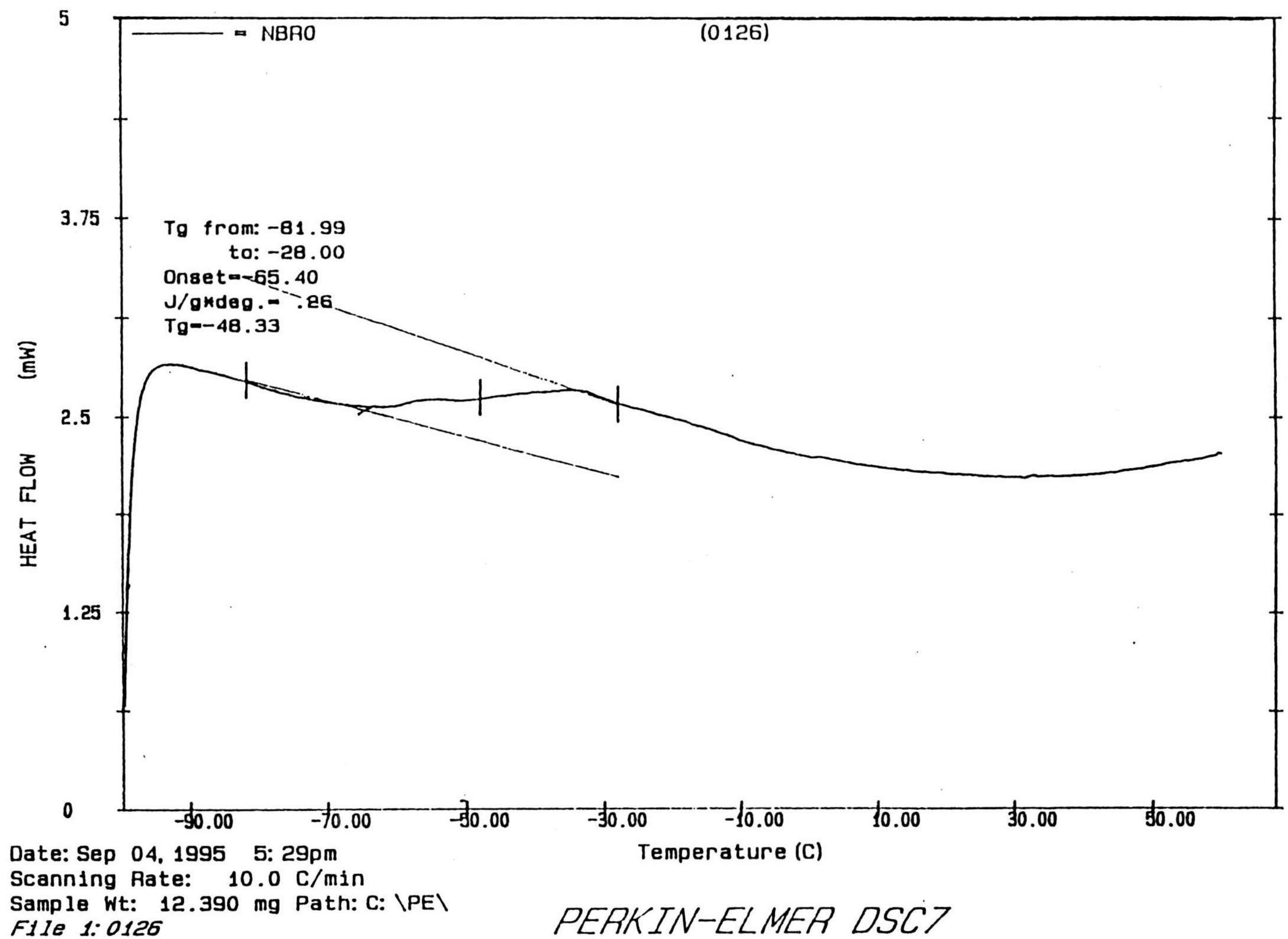

Fig 4.11: DSC thermogram of plasticized PVC.

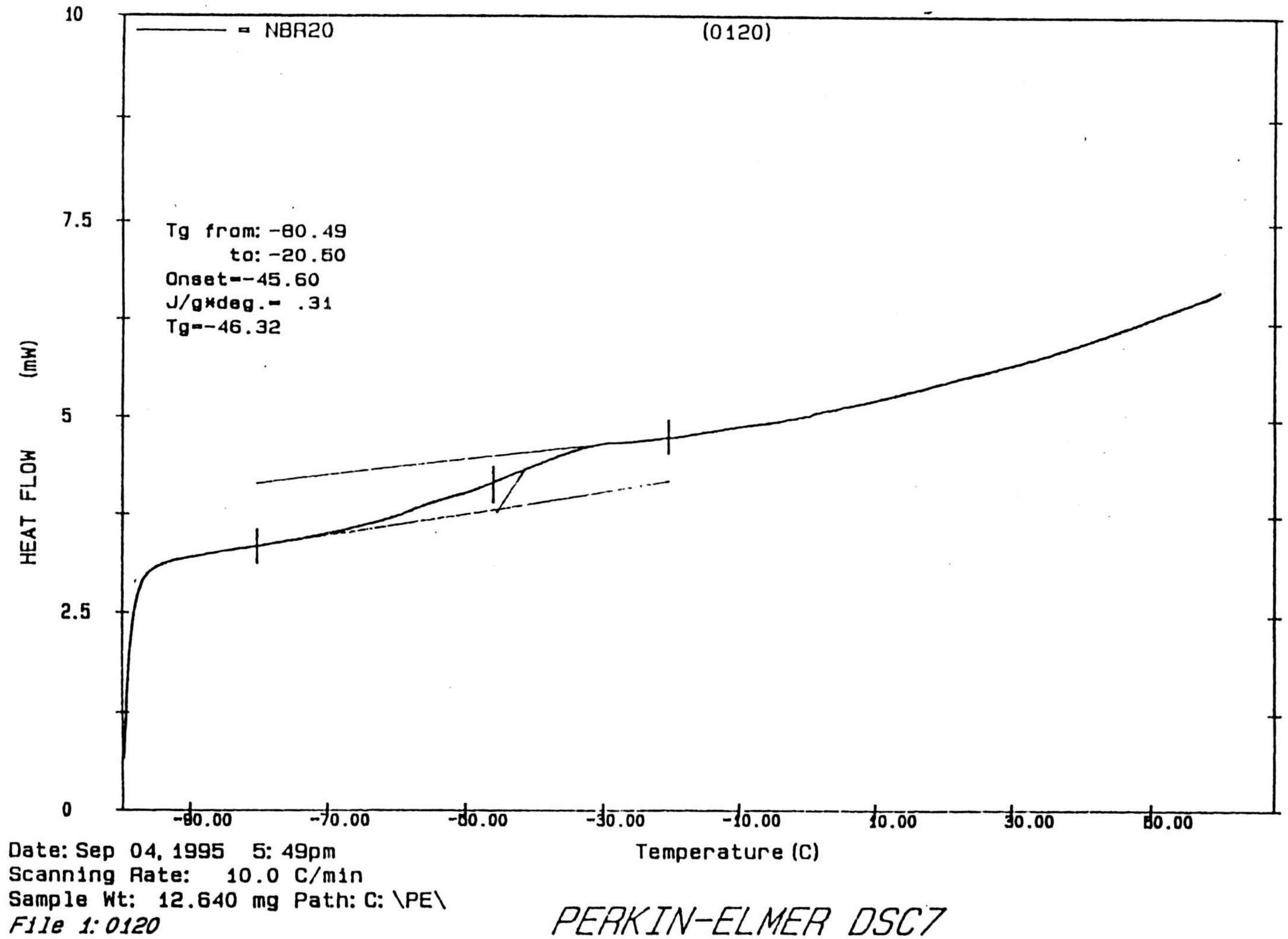

Fig 4.12: DSC thermogram of plasticized PVC with 20 phr NBR.

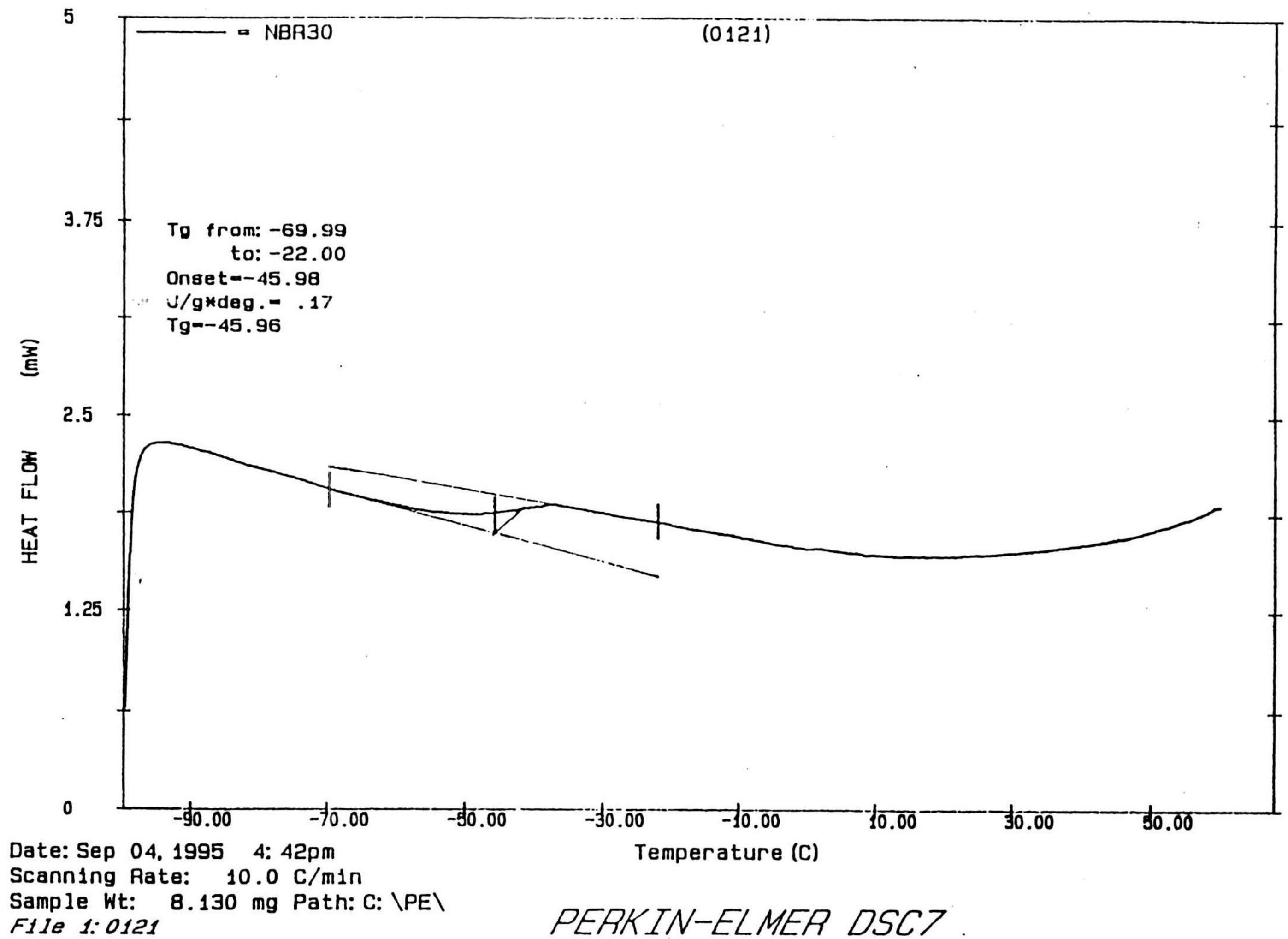

Fig 4.13: DSC thermogram of plasticized PVC with 30 phr NBR.

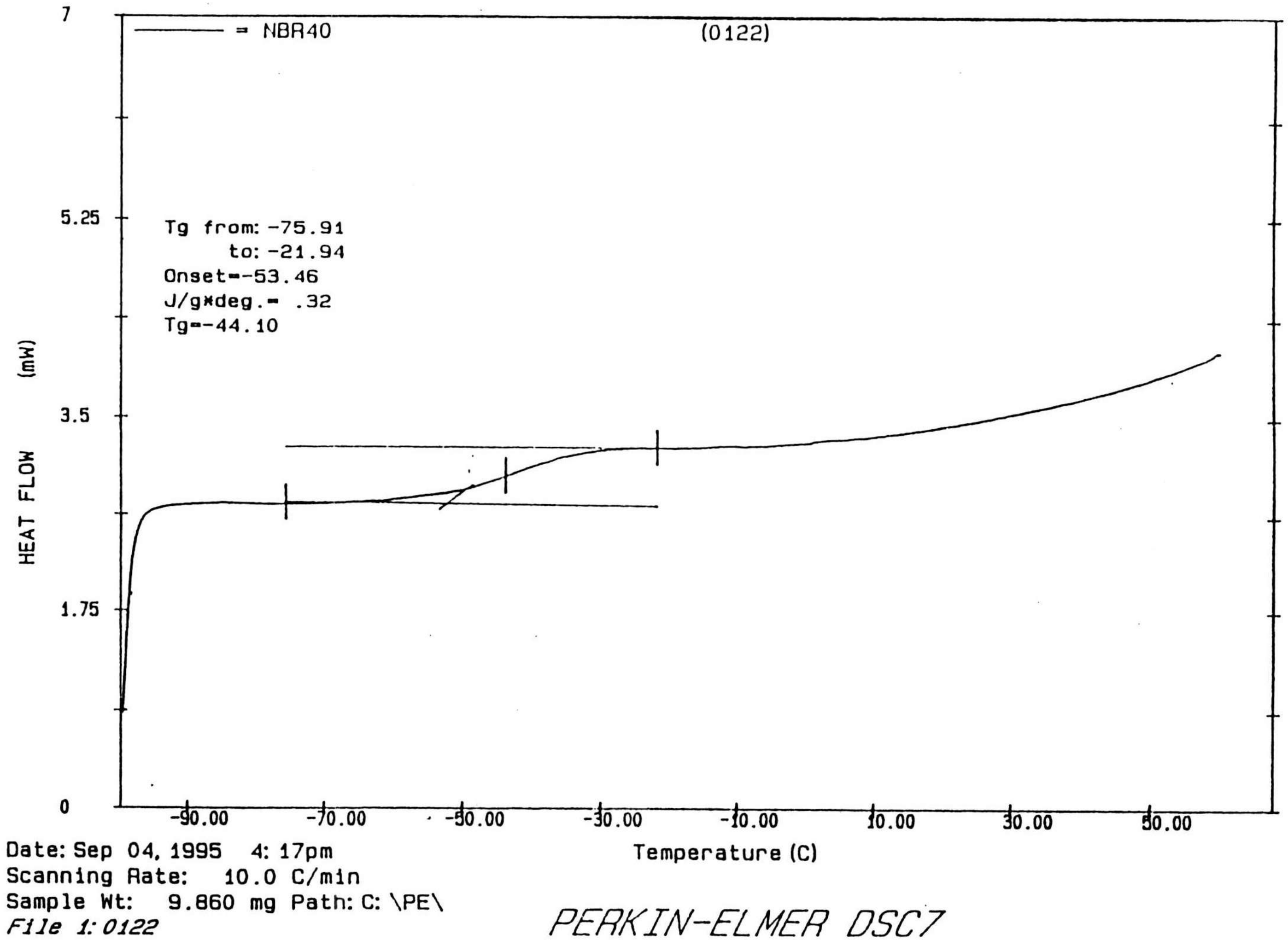

Fig 4.14: DSC thermogram of plasticized PVC with 40 phr NBR .

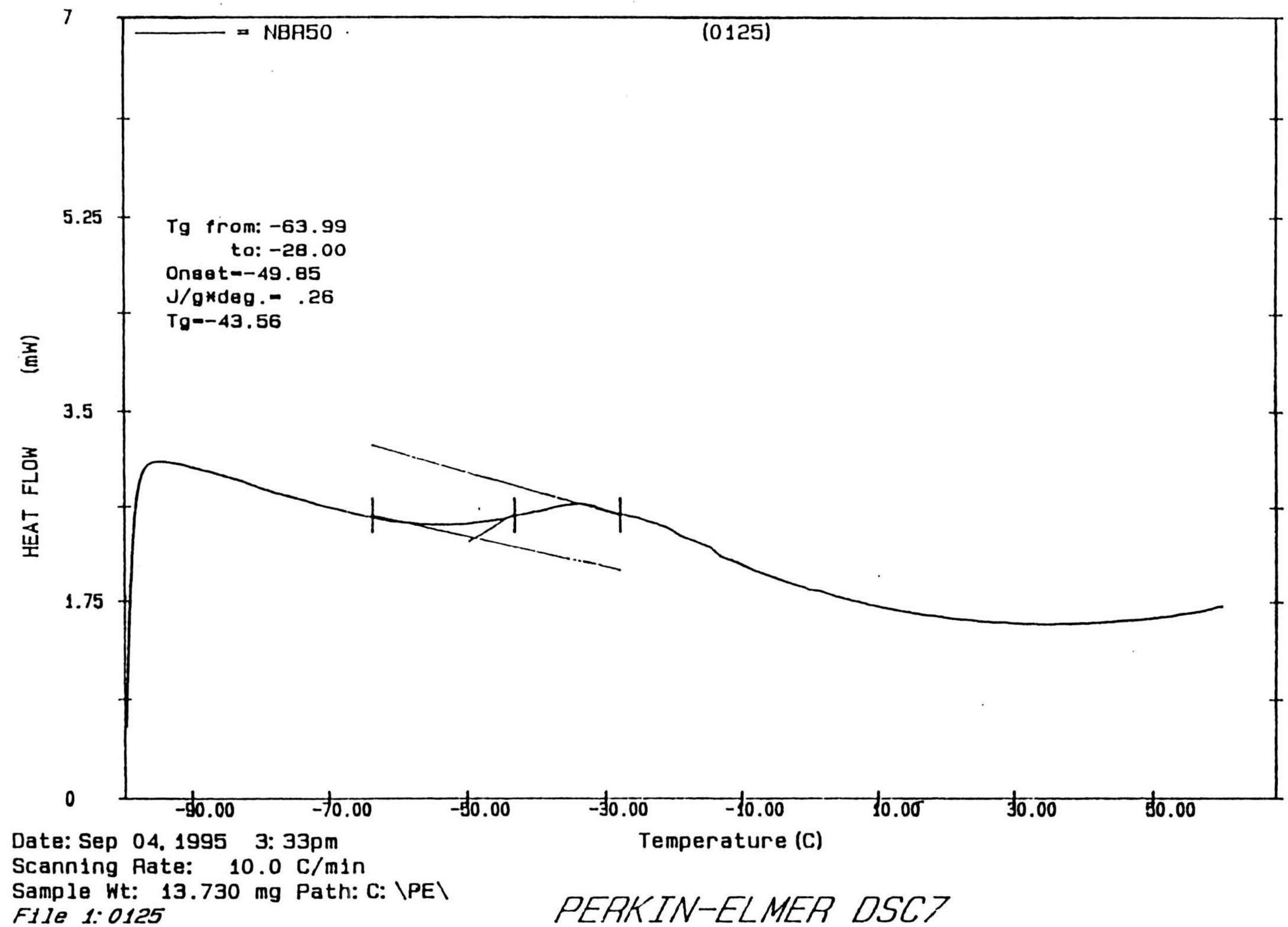

Fig 4.15: DSC thermogram of plasticized PVC with 50 phr NBR.

In Fig 4.10, the T_g of the NBR is observed at -31.39°C. For plasticized PVC, two T_g 's have been observed at -48.33°C. The compatibility between plasticized PVC and NBR was evident in the shift of the T_g of the plasticized PVC. The trend of the shift is towards the T_g of NBR. Another evidence which supports the idea of compatibility between the two polymers is that there is lack of two values of the T_g 's between the T_g of the plasticized PVC and that of the NBR. The T_g 's of the plasticized PVC and those with the addition of NBR are evaluated from the DSC thermalscans. They are plotted against the NBR content as shown in Fig 4.16.

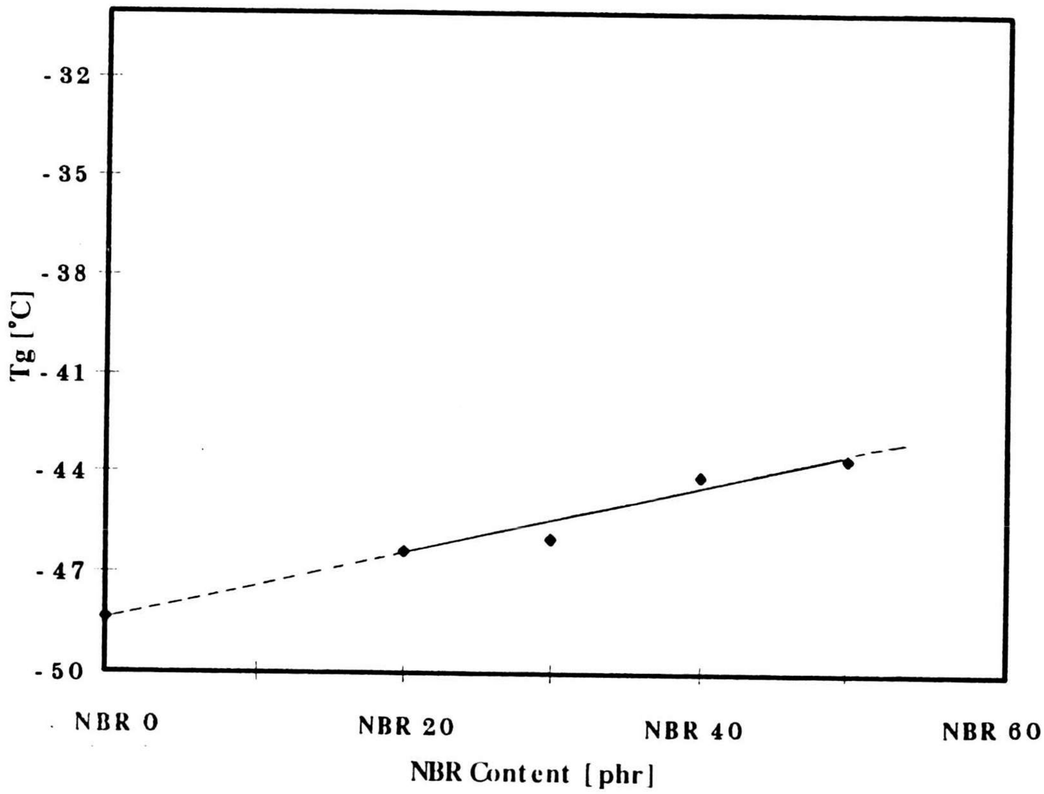

Fig 4.16: The glass transition temperature of the plasticized PVC and plasticized PVC mixed with various amounts of NBR.

The above results are in good agreement with the study by Zerkzewski [68] which reported that nitrile elastomers containing 23 to 45 % acrylonitrile content were compatible with PVC at all ratioes. Landi [29] studied the compatibility of NBR with 34% acrylonitrile content in polymer mixing by using the differential scanning calorimeter. The compatibility and miscibility between the two polymers was found as indicated by a single glass transition in the polymer blend.

4.3.2 TGA

TGA7 was used to analyze the content of NBR in the series of plasticized PVC prepared in the present study. Fig 4.17 shows the thermogram obtained from the TGA. The thermogram evidently confirms the level of the NBR content in all the test samples. The TGA result indicates the weight change that occurred around 350°C and 480°C due to the degradation of PVC. The weight change was found to decrease as the NBR content in the test samples increases.

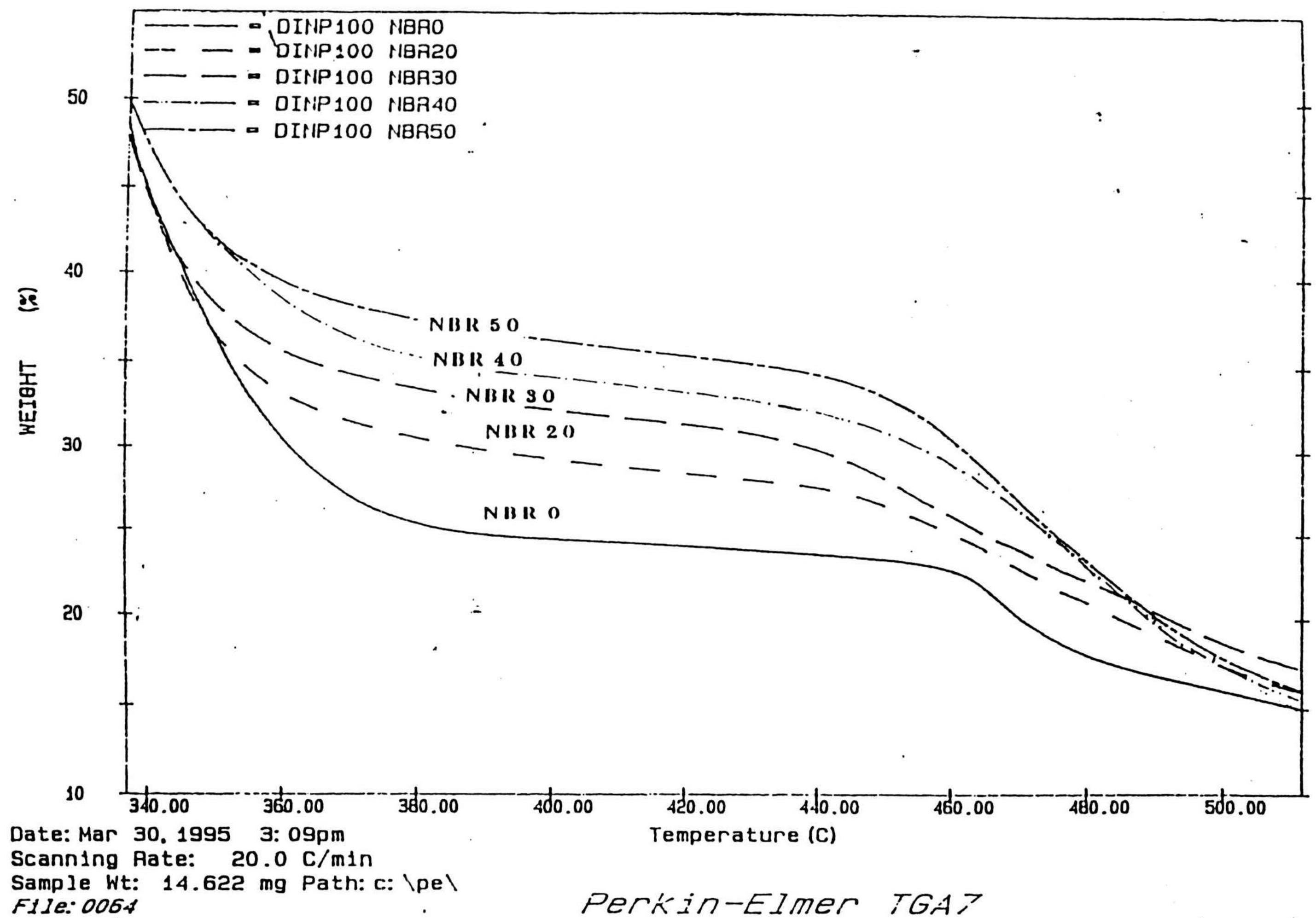

Fig 4.17: TGA thermogram shows the decomposition of NBR in plasticized PVC where NBR content is 0, 20, 30, 40 and 50 phr.

4.4 Analytical

Representative FTIR spectrum of the plasticized PVC with and without NBR are illustrated in Figs 4.18 to 4.22. Strong absorption characteristic is observed at 2238 cm^{-1}. This clearly indicates the presence of CN absorption peak from the NBR. Stronger absorption is detected with greater amount of NBR content. The absorption is the lowest in Fig 4.19 while that in Fig 4.22 is the highest.

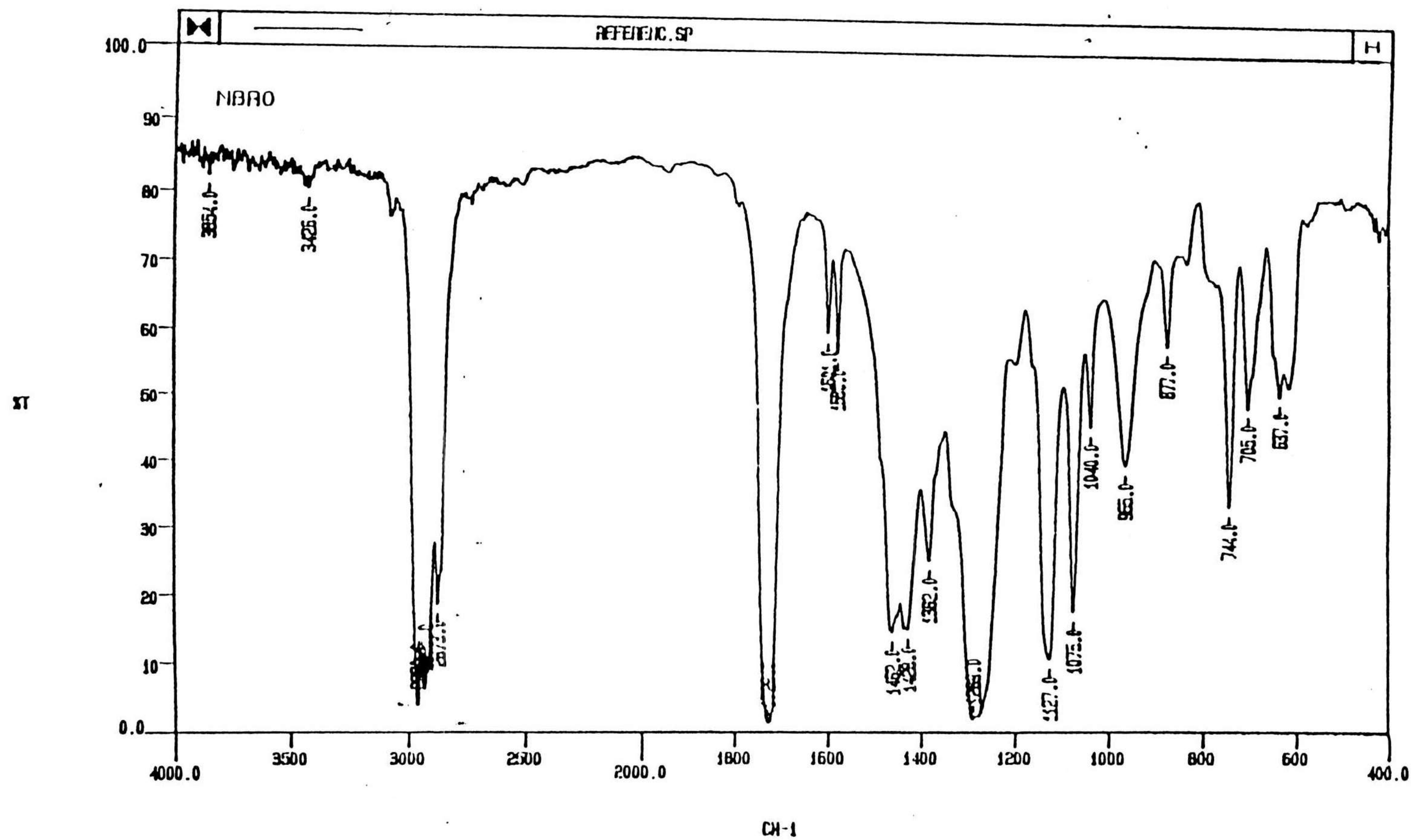

Fig 4.18: FTIR spectra of plasticized PVC without NBR.

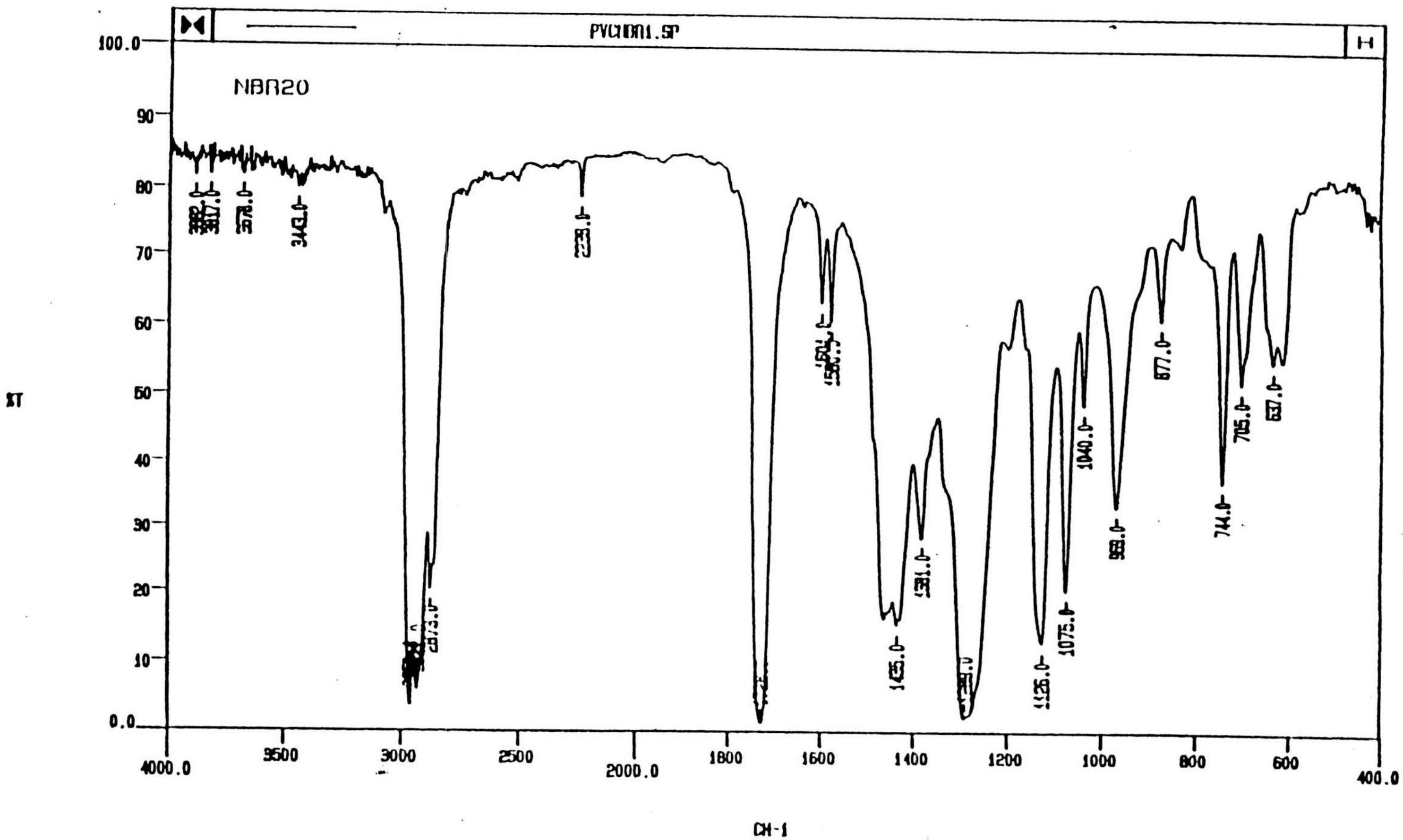

Fig 4.19: FTIR spectra of plasticized PVC with 20 phr NBR.

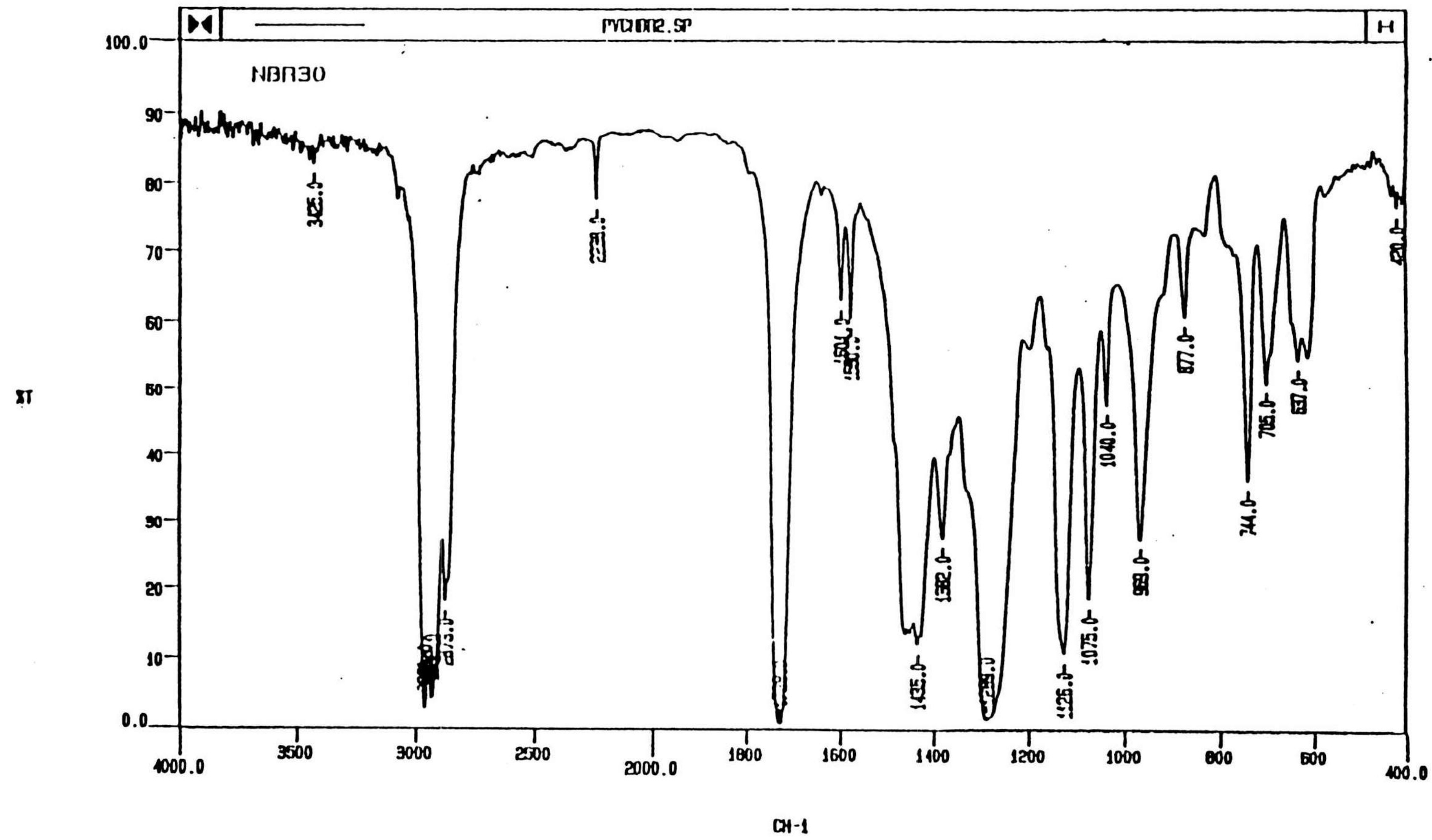

Fig 4.20: FTIR spectra of plasticized PVC with 30 phr NBR.

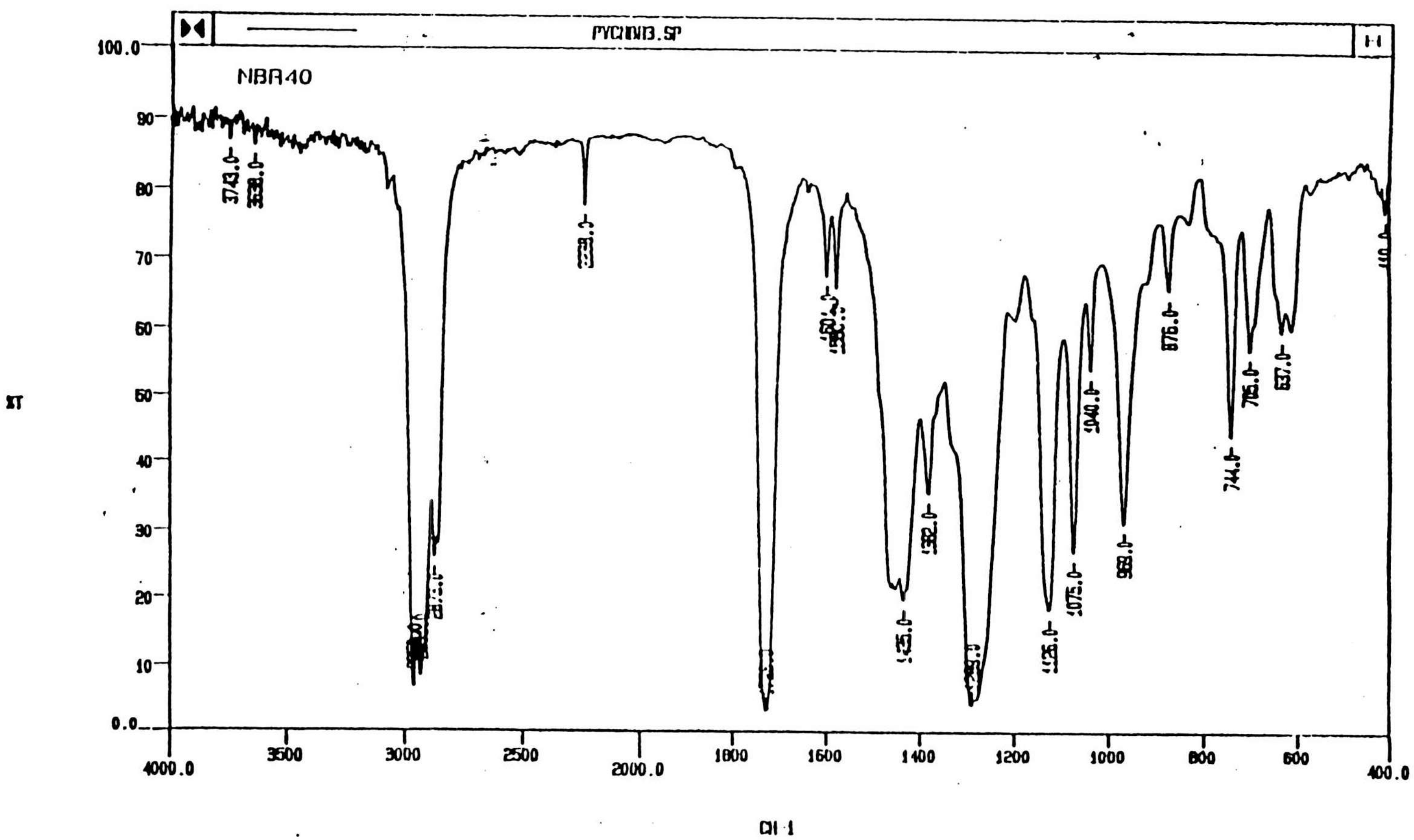

Fig 4.21: FTIR spectra of plasticized PVC with 40 phr NBR.

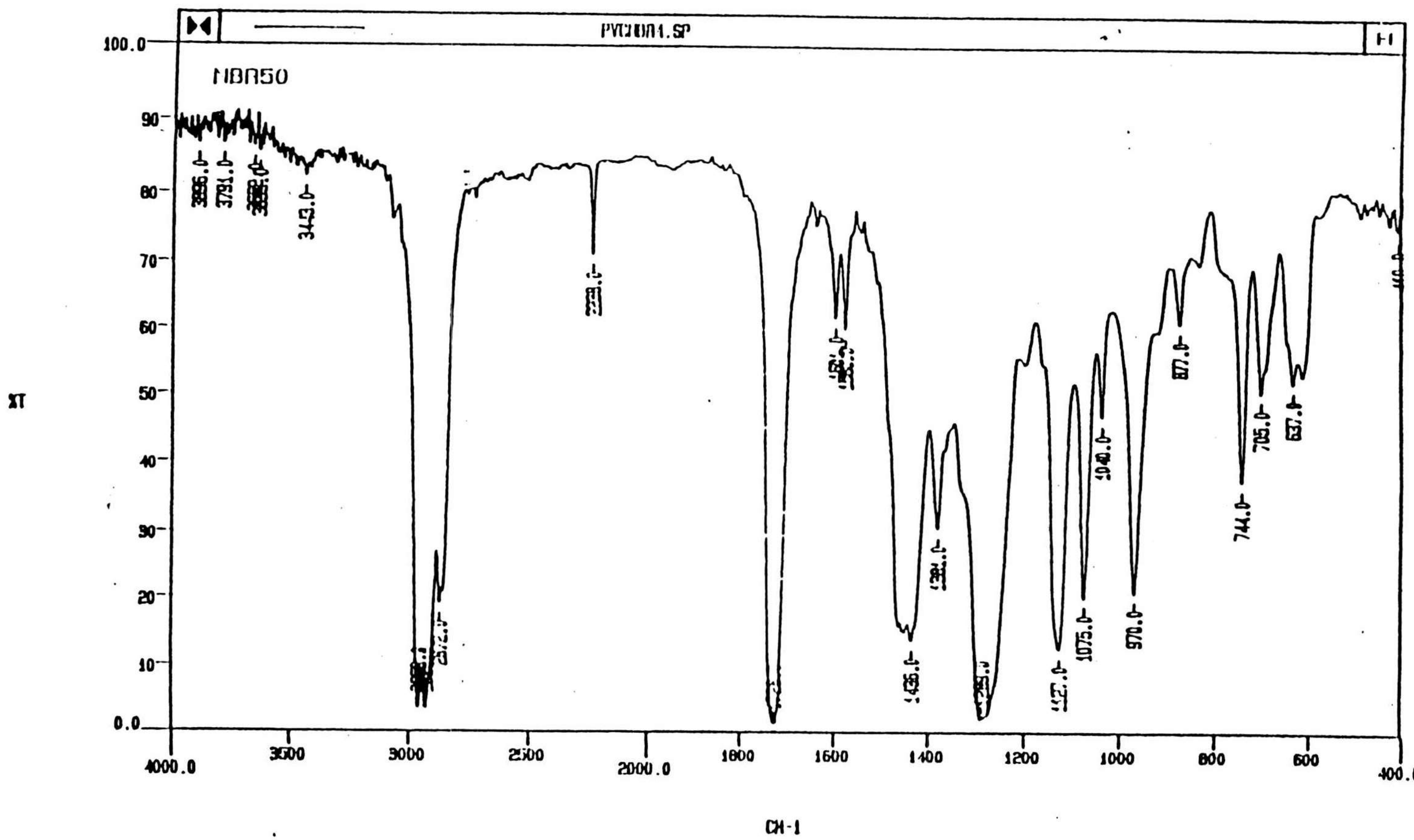

Fig 4.22: FTIR spectra of plasticized PVC with 50 phr NBR.

4.5 Oil Resistance Test

Since monomeric plasticizers are easily extracted from plasticized PVC compounds when they are in contact with aggressive materials such as solvent, gasoline and oil, it seems desirable to detect any changes in properties and how resistant the prepared series of plasticized PVC with NBR are to these solvents. Here, it was desired to determine comparatively the changes in the physical properties before and after immersing the specimens in three petrol reagents i.e. motor oil, unleaded gasoline and hexane.

Drastic deterioration in mechanical and physical properties of plasticized PVC with and without NBR implies that there is limited use of these plasticized PVC for the production of articles for industrial purposes especially those to be used in aggressive environments.

4.5.1 Mechanical Properties

4.5.1.1 Resistance of Tensile Properties

Fig 4.23 is the plot of the tensile strength before and after oil aging and the amount of NBR.

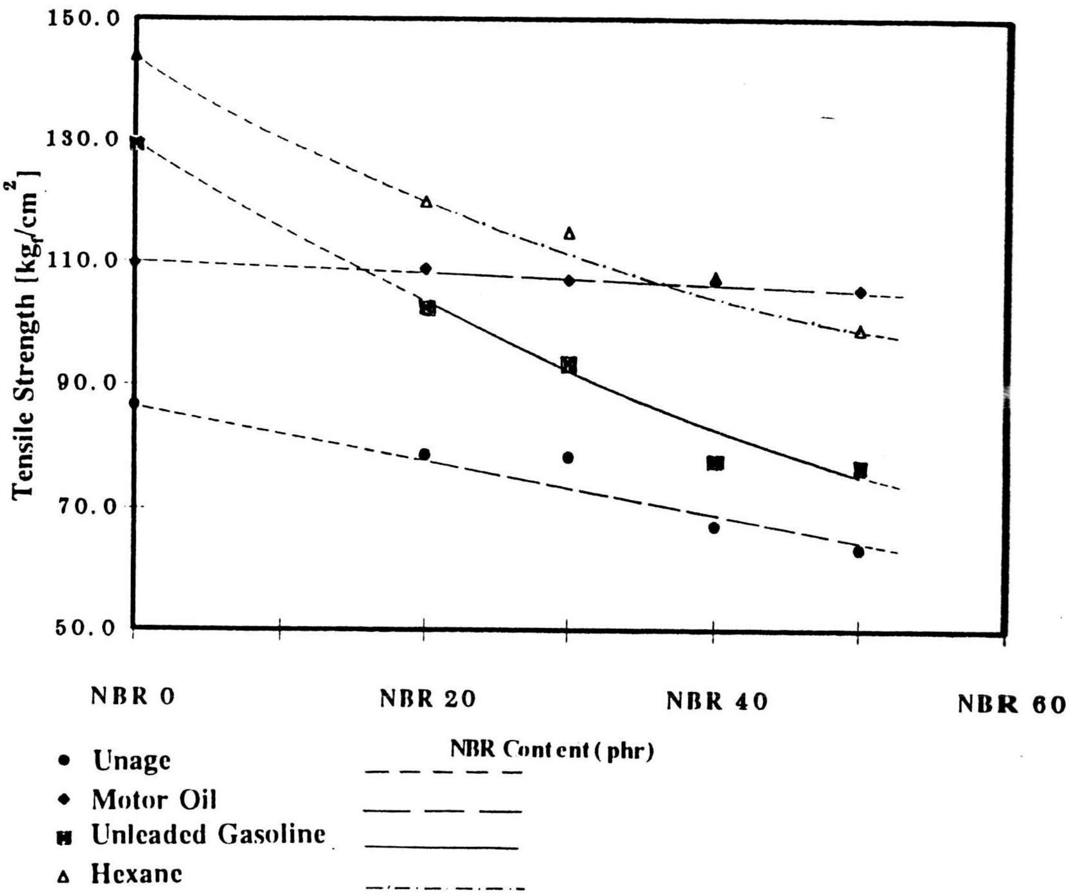

Fig 4.23: The relationship between the tensile strength before and after oil aging and the amount of NBR in plasticized PVC.

The immersion of samples in three petrol reagents leads to a higher tensile strength when compared with the unimmersed sample.

With the amount of NBR, the tensile strength of samples which were immersed in unleaded gasoline and hexane was found to decrease. However, the immersion in the motor oil seems to have no effect in the tensile properties of the plasticized PVC with various amount of NBR.

In conclusion, the magnitude of the effect of the three petrol reagents to the tensile strength for plasticized PVC can be summarized in the following order:

Hexane> Unleaded Gasoline> Motor Oil

For the plasticized PVC with NBR, it can be summarized slightly differently in the following order:

Hexane> Motor Oil> Unleaded Gasoline

Fig 4.24 shows the change in the tensile strength of plasticized PVC and plasticized PVC and various amounts of NBR content immersed in three petrol reagents.

For the samples immersed in motor oil, the change in tensile strength becomes greater after the impregnation. The change in the tensile strength is even greater as the NBR content is increased. However, the change in the tensile strength at 30 phr NBR content was slightly less than that of the 20 phr NBR content.

In case of an immersion in hexane, the results indicate that the addition of NBR by 20 and 30 phr decreases the change in the tensile strength. However, when the addition of NBR is increased to 40 phr, the change in the tensile strength is increased. When the NBR content is raised upto 50 phr, the change decreases slightly. In the presence of hexane, the tensile strength seems to be reduced to a minimum level when NBR content is around 30 phr.

The immersion in unleaded gasoline can effectively change the tensile properties as well. The change in the tensile strength tends to decrease as the content of NBR increases. In the presence of unleaded gasoline, the change in tensile strength is reduced to its minimum level when NBR content is about 40 phr.

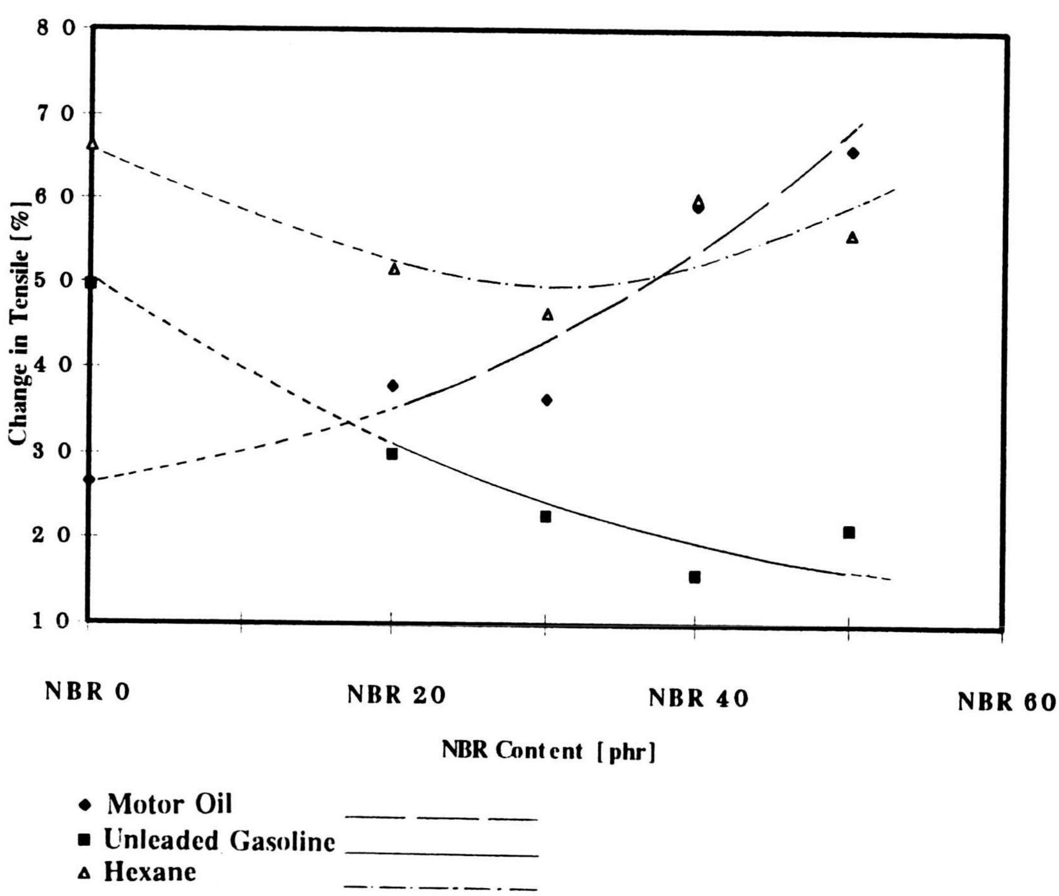

Fig 4.24: The relationship between the change in the tensile strength after oil aging and the amount of NBR in plasticized PVC.

4.5.1.2 Resistance of Elongation at Break

Fig 4.25 shows the elongation at break for plasticized PVC and plasticized PVC and various NBR contents before and after aging in three petrol reagents.

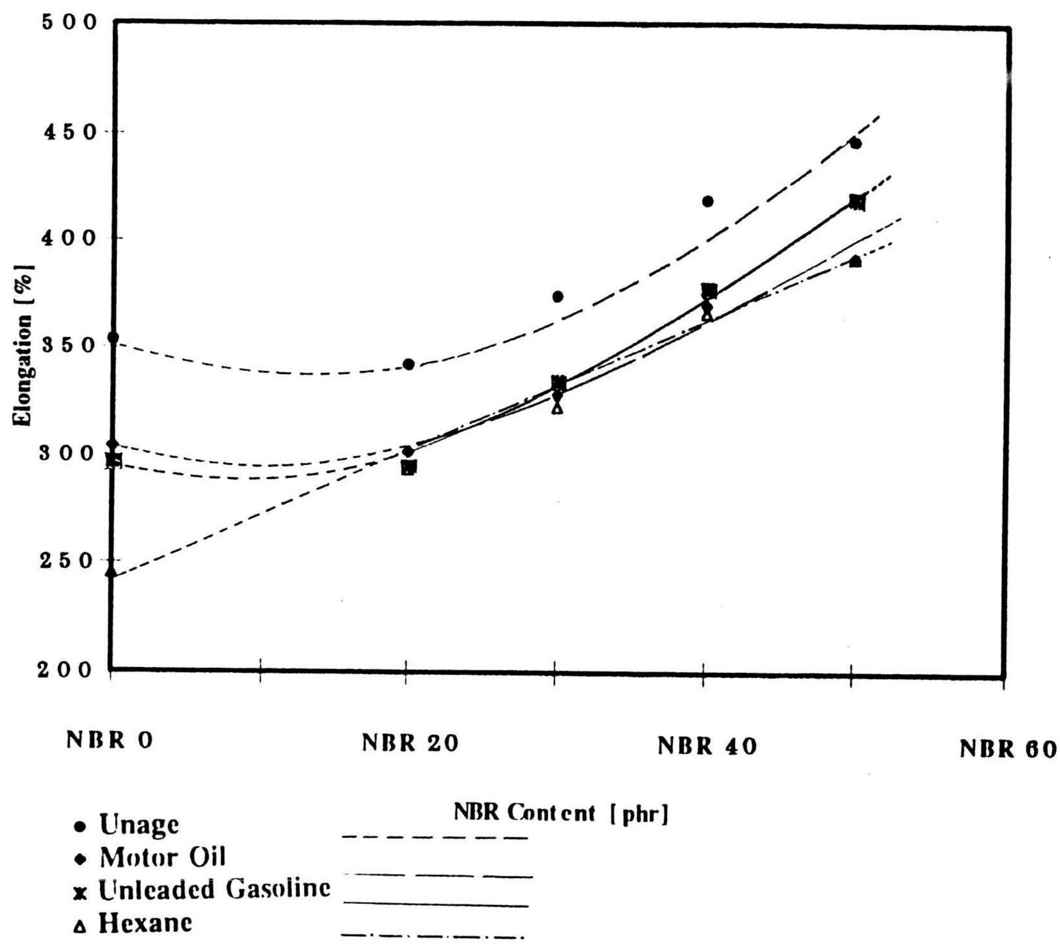

Fig 4.25: The relationship between the elongation at break before and after oil aging and the amount of NBR in plasticized PVC.

The elongation at break of the samples immersed in three petrol reagents are all lower than that of unimmersed samples. The immersion of plasticized PVC with and without NBR in all three petrol reagents causes an increase in the elongation at break.

The addition of NBR to plasticized PVC (both before and after aging) leads to a decrease in the elongation at break. The elongation at break of samples immersed in each petrol reagent does not exhibit much difference over the applied range of 20 to 40 phr of NBR. But at 50 phr NBR content, the elongation at break of the samples immersed in unleaded gasoline is higher than that of samples immersed in other petrol reagents.

Fig 4.26 shows the change in the elongation at break of the plasticized PVC and various NBR contents after aging in three petrol reagents.

For the immersion in unleaded gasoline, the change in the elongation at break is lowered when the NBR content is increased. For hexane, the higher the amount of NBR, the lower the change in elongation at break was found. For hexane, in the case of plasticized PVC without NBR, the change in elongation at break decreases by 30.6% which is the highest change in the series of samples. The higher amount of NBR results in a lower change in the elongation at break but the decrease is at a lower rate than that of the plasticized PVC without NBR.

A different trend is observed in the change in the elongation at break for specimens immersed in motor oil. An addition of NBR seems to have only little effect to the change in the elongation at break which was found to be a maximum of -11.7% for 40 phr NBR. For plasticized PVC, the maximum change in the elongation at break was found to be -14.1% for 0 phr NBR.

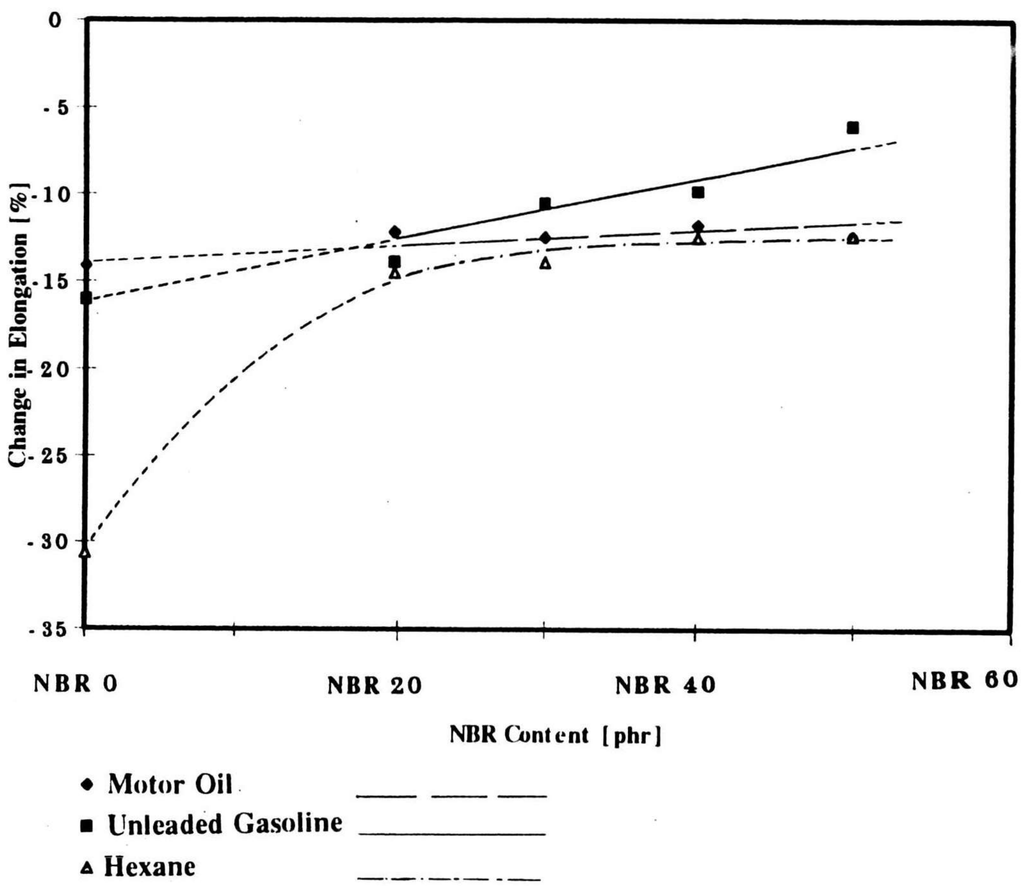

Fig 4.26: The relationship between the change in elongation at break after oil aging and the amount of NBR in plasticized PVC.

4.5.1.3 Resistance of Modulus at 50% Elongation

Fig 4.27 is the plot of the relationship between the modulus at 50% elongation before and after oil aging and the various amounts of NBR.

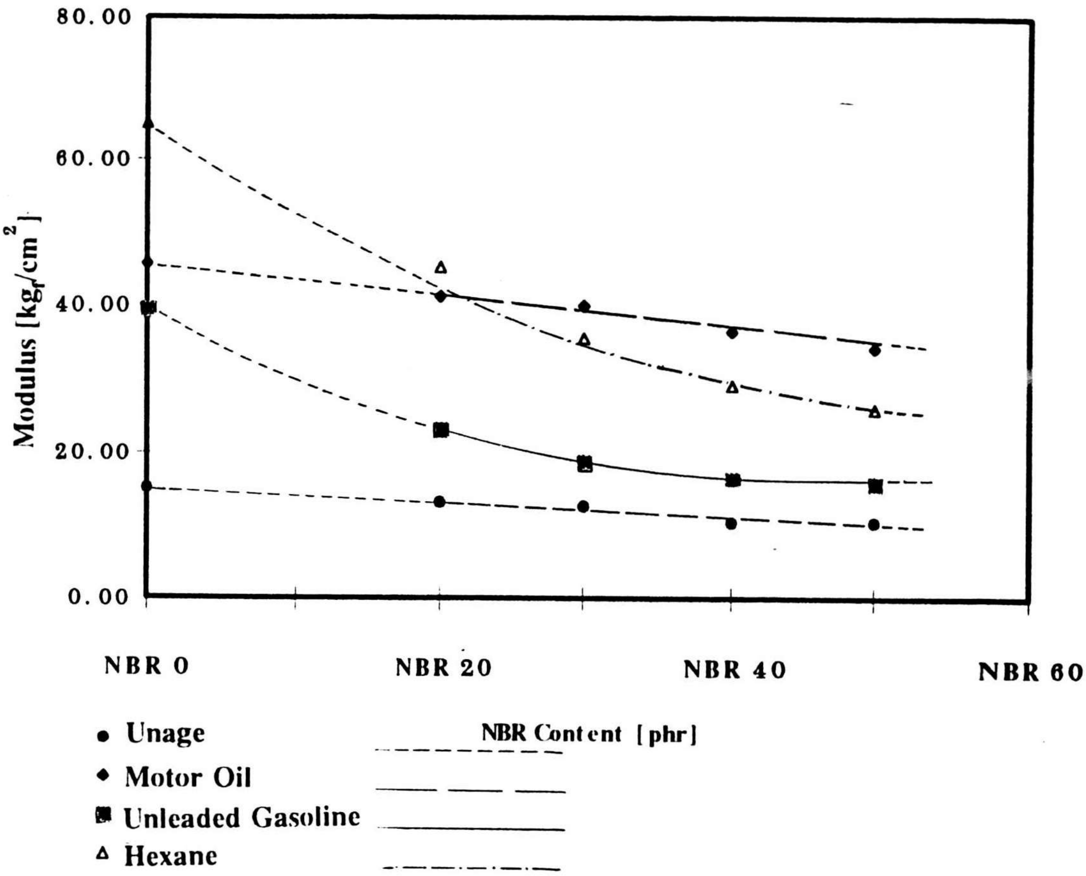

Fig 4.27: The relationship between the modulus at 50% elongation before and after oil aging and the amount of NBR in plasticized PVC.

The modulus of the samples immersed in three petrol reagents are all higher than that of the unimmersed ones.

With the higher amount of NBR, the modulus was found to be lower for all the samples. The immersion in unleaded gasoline and hexane leads to a decrease in the modulus as the NBR content was increased. The immersion in motor oil shows the same trend, that is the modulus decreases with the increase in the amount of NBR but at a lower rate than that of the samples immersed in unleaded gasoline and hexane.

In conclusion, the magnitude of the effect of the three petrol reagents to the modulus at 50% elongation for plasticized PVC without NBR can be summarized in the following order:-

Hexane> Motor Oil> Unleaded Gasoline

For plasticized PVC with NBR, the effect of three petrol reagents to the modulus at 50% elongation can be concluded differently in the following order:-

Motor Oil> Hexane> Unleaded Gasoline

Fig 4.28 is the plot of the changes in the modulus at 50% elongation after oil aging with three petrol reagents and the amount of NBR.

The immersion of all samples in unleaded gasoline and hexane leads to a decrease in the change in the modulus. The addition of 20 and 30 phr NBR lowers the change in modulus. A slight change is observed when the NBR contents is increased to 30 to 50 phr. However, the immersion in hexane has a higher effect to the change in the modulus than that observed when immersed in unleaded gasoline.

For the immersion in motor oil, an opposite trend was observed for the change in the modulus. The higher the amount of NBR, the greater was the change in the modulus.

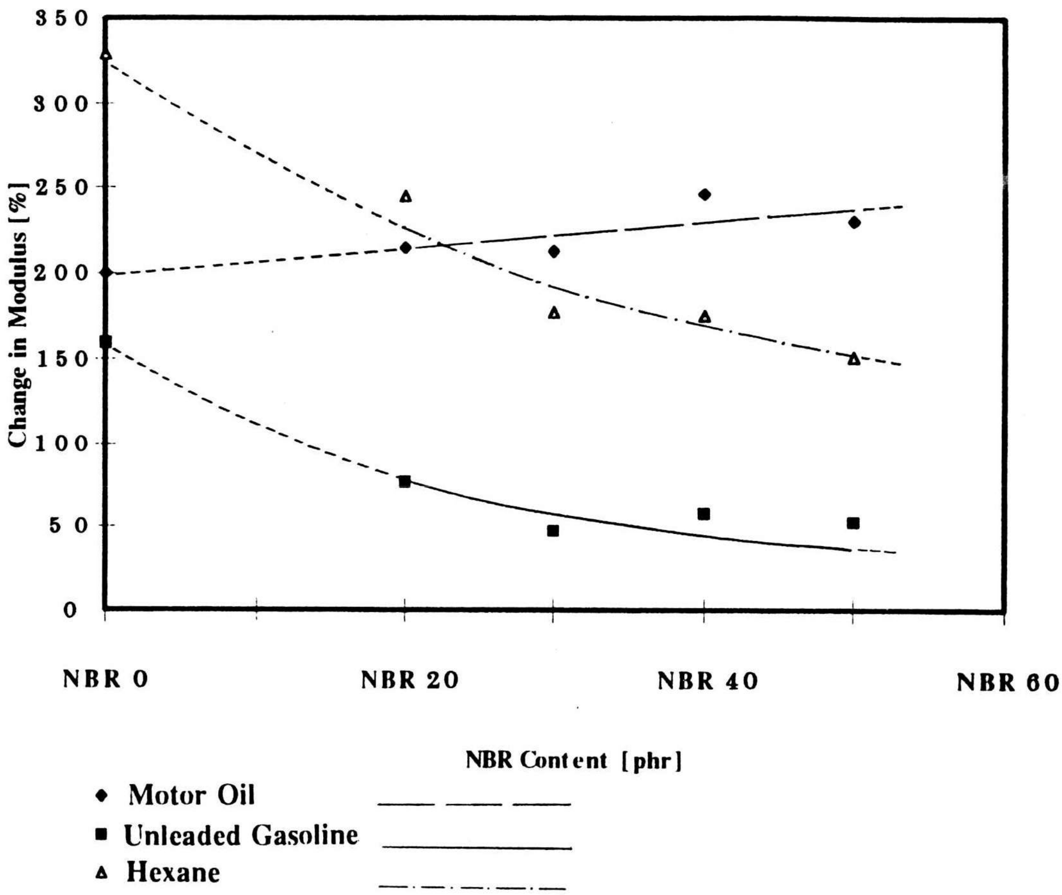

Fig 4.28: The relationship between the change in modulus at 50% elongation after oil aging and the amount of NBR in plasticized PVC.

4.5.1.4 Resistance of Modulus at 100% Elongation

Fig 4.29 is the plot of the modulus at 100% elongation before and after oil aging with the three petrol reagents and the amount of NBR.

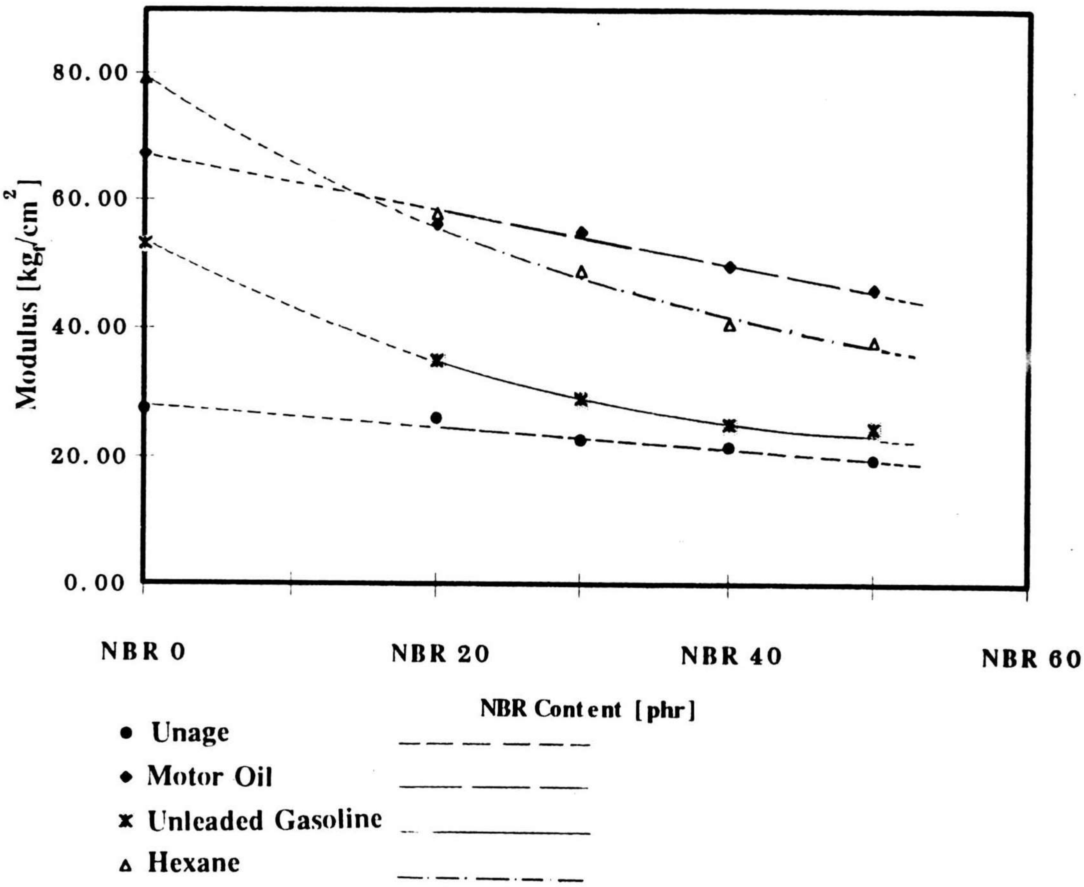

Fig 4.29: The relationship between the modulus at 100% elongation before and after oil aging and the amount of NBR in plasticized PVC.

The above results indicate that the immersion of all samples in the three petrol reagents leads to an increase in the modulus when compared with the unimmersed samples.

With the higher amount of NBR, the modulus was found to be lower for all the samples. The immersion in unleaded gasoline and hexane leads to a decrease in the modulus as the NBR content was increased. The immersion in motor oil also shows the same trend, i.e. the modulus decreases with the increase in the amount of NBR but at a lower rate than that of the samples immersed in unleaded gasoline and hexane.

In conclusion, the magnitude of the effect of the three petrol reagents to the modulus at 100% elongation for plasticized PVC without NBR can be summarized in the following order:-

Hexane> Motor Oil> Unleaded Gasoline

For plasticized PVC with NBR content more than 30 phr, the effect of the three petrol reagents to the modulus at 100% elongation can be concluded differently in the following order:-

Motor Oil> Hexane> Unleaded Gasoline

Fig 4.30 is the plot of the change of the modulus at 100% elongation after oil aging with the three petrol reagents and the amount of NBR.

The immersion of samples in unleaded gasoline and hexane leads to a decrease in the change in modulus at 100% elongation while the immersion in motor oil seems to have no effect on the change in modulus at 100% elongation.

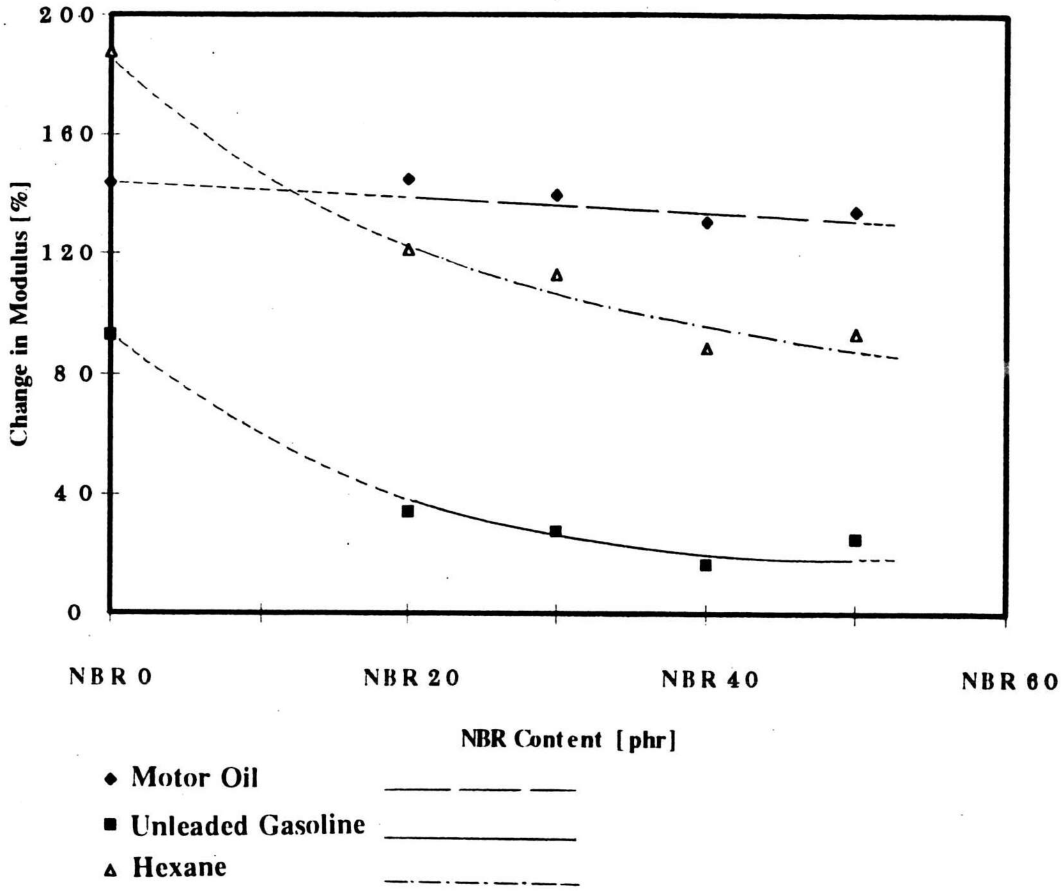

Fig 4.30: The relationship between the change in modulus at 100% elongation after oil aging and the amount of NBR in plasticized PVC.

4.5.1.5 Resistance to Modulus at 200% Elongation

Fig 4.31 is the plot of the modulus at 200% elongation before and after oil aging with the three petrol reagents and the amount of NBR.

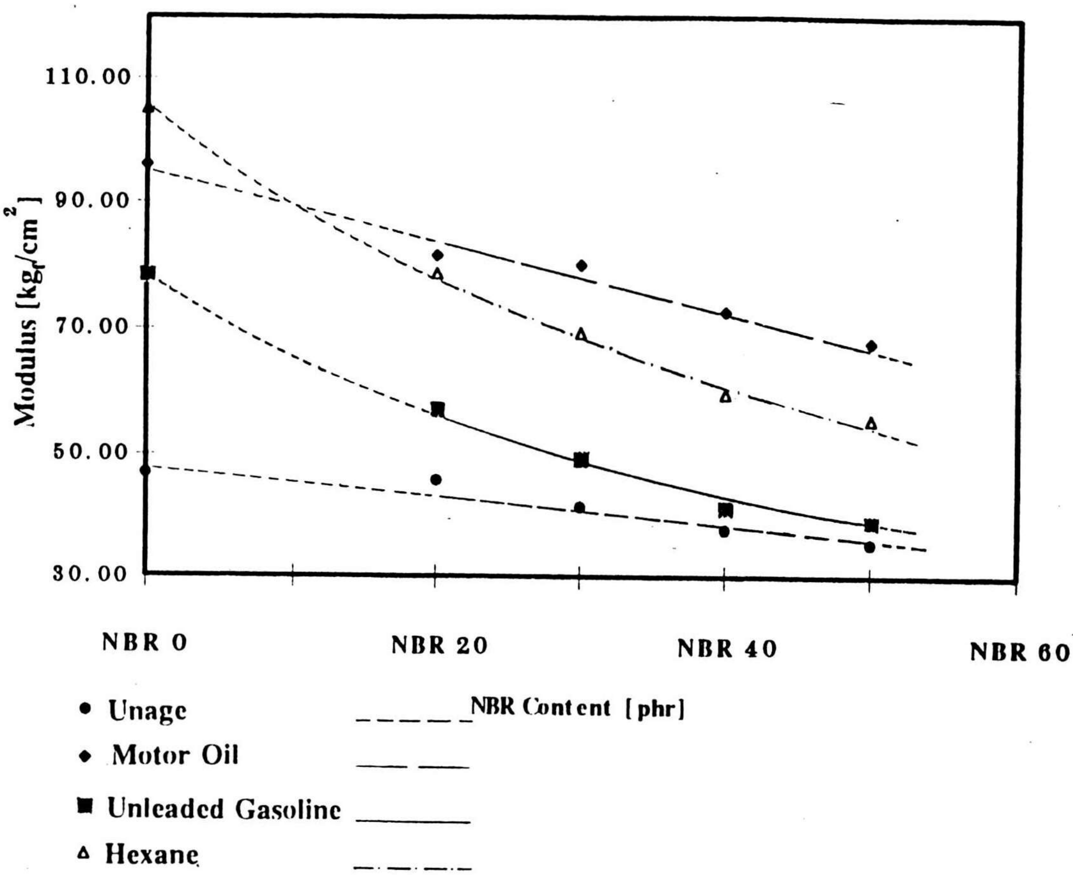

Fig 4.31: The relationship between the modulus at 200% elongation before and after oil aging and the amount of NBR in plasticized PVC.

The modulus at 20% elongation of the samples immersed in the three petrol reagents are all higher than that of the unimmersed ones.

With the higher amount of NBR, the modulus was found to be lower for all the samples. The immersion in unleaded gasoline and hexane leads to a decrease in the modulus at 200% elongation as the NBR content was increased. The immersion in motor oil shows the same trend, i.e. the modulus decreases with the increase in the amount of NBR but at a lower rate than that of the samples immersed in unleaded gasoline and hexane.

In conclusion, the magnitude of the effect of the three petrol reagents to the modulus at 200% elongation for plasticized PVC without NBR can be summarized in the following order:-

Hexane> Motor Oil> Unleaded Gasoline

For plasticized PVC with NBR, the effect of the three petrol reagents to the modulus at 200% elongation can be concluded differently in the following order:-

Motor Oil> Hexane> Unleaded Gasoline

Fig 4.32 is the plot of the change of modulus at 200% elongation after oil aging with the three petrol reagents and the amounts of NBR.

The immersion of all samples in unleaded gasoline and hexane leads to a decrease in the change in the modulus at 200% elongation. The addition of 20 and 30 phr NBR lowers the change in the modulus. A slight change is observed when the NBR content is increased to 30 to 50 phr.

For the immersion in motor oil, an addition of 20 phr NBR to plasticized PVC lowers the change in the modulus at 200% elongation. When the NBR content is increased upto 50 phr, the immersion in motor oil seems to have no effect on the change in modulus at 200% elongation.

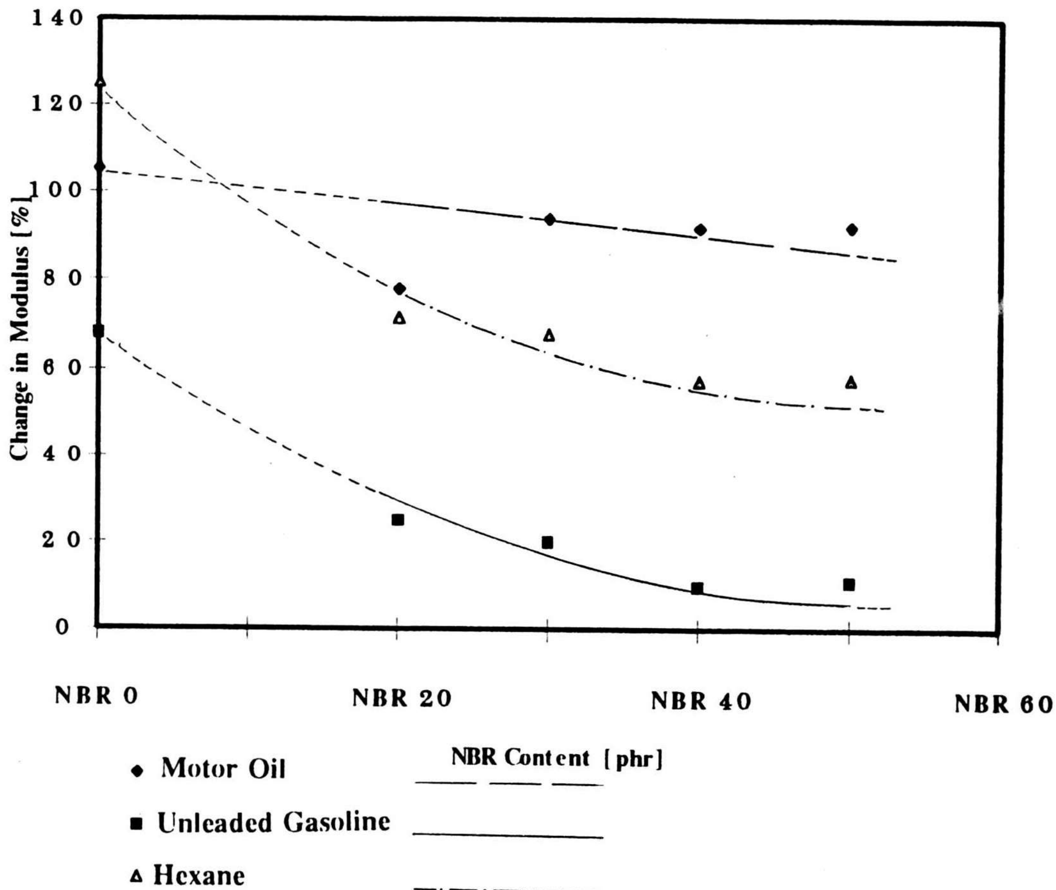

Fig 4.32: The relationship between the change in modulus at 200% elongation after oil aging and the amount of NBR in plasticized PVC.

In conclusion, the magnitude of the effect of the three petrol reagents to the change in modulus at 200% elongation for plasticized PVC without NBR can be summarized in the following order:-

Hexane> Motor Oil> Unleaded Gasoline

For plasticized PVC with NBR, the effect of the three petrol reagents to the change in modulus at 200% elongation can be concluded differently in the following order:-

Motor Oil> Hexane> Unleaded Gasoline

4.5.2 Physical Properties

4.5.2.1 Weight Change

Fig 4.33 shows the plot between the weight change after aging with the three petrol reagents and the NBR content.

After the samples were immersed in each petrol reagents, the weight of each sample was lower than that of the unimmersed ones.

With the higher amount of NBR, the immersion of all sample in hexane and unleaded gasoline leads to a lower weight loss, while the immersion in motor oil seems to have no effect on the change in weight.

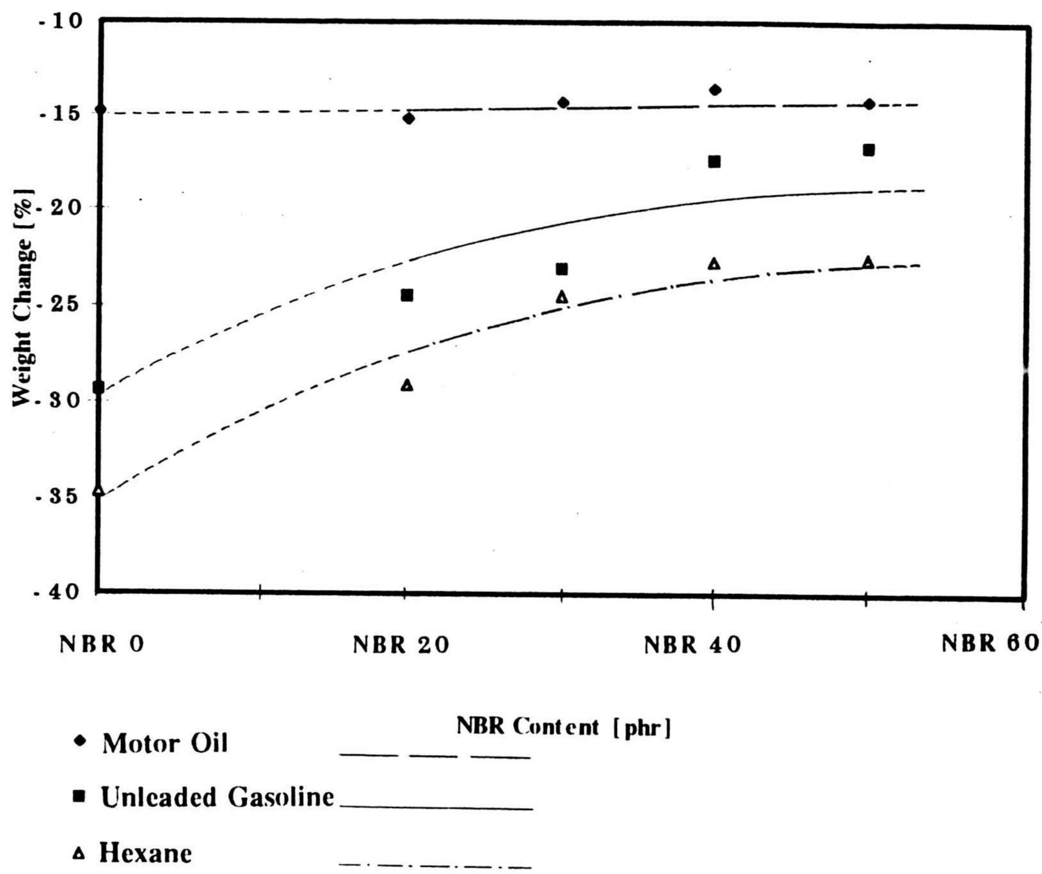

Fig 4.33: The relationship between the weight change after oil aging and the amount of NBR in plasticized PVC.

In conclusion, the magnitude of the effect of the three petrol reagents to the weight loss for plasticized PVC without NBR can be summarized in the following order:-

Hexane> Unleaded Gasoline> Motor Oil

For plasticized PVC with NBR, the effect of the three petrol reagents to the weight loss can be concluded identically in the following order:-

Hexane> Unleaded Gasoline> Motor Oil

The cause of the weight loss of samples immersed in the petrol reagents is believed to be due to the extraction of the plasticizer in the PVC by the two petrol reagents, i.e. unleaded gasoline and hexane. To support the above results, the hexane left over after each immersion of the test samples was analyzed. Hexane has a low boiling point so it is easy to evaporate. FTIR was used to identify any additional material in the left over hexane after the hexane itself was allowed to evaporate completely. The spectra in Fig 4.34 clearly shows the characteristic of DINP plasticizer which had been extracted to hexane during the hexane aging process.

In conclusion, for the immersion of all samples in unleaded gasoline and hexane, it was found that the higher the amount of NBR, the lower is the weight loss after aging in the aforementioned reagents. This is believed to be due to the presence of NBR which has helped absorbing the plasticizer. The increase in the NBR content means that there is more NBR to absorb more plasticizer. Thus, a less amount of plasticizer was extracted and resulted in a lower weight loss.

A different result was found for an immersion in motor oil. The amount of NBR does not seem to have much effect on the weight change. This is perhaps because the NBR has less resistance to motor oil. This finding supports the above experimental results in Section 5.1.1 which shows the trend of constant tensile strength after samples were immersed in motor oil.

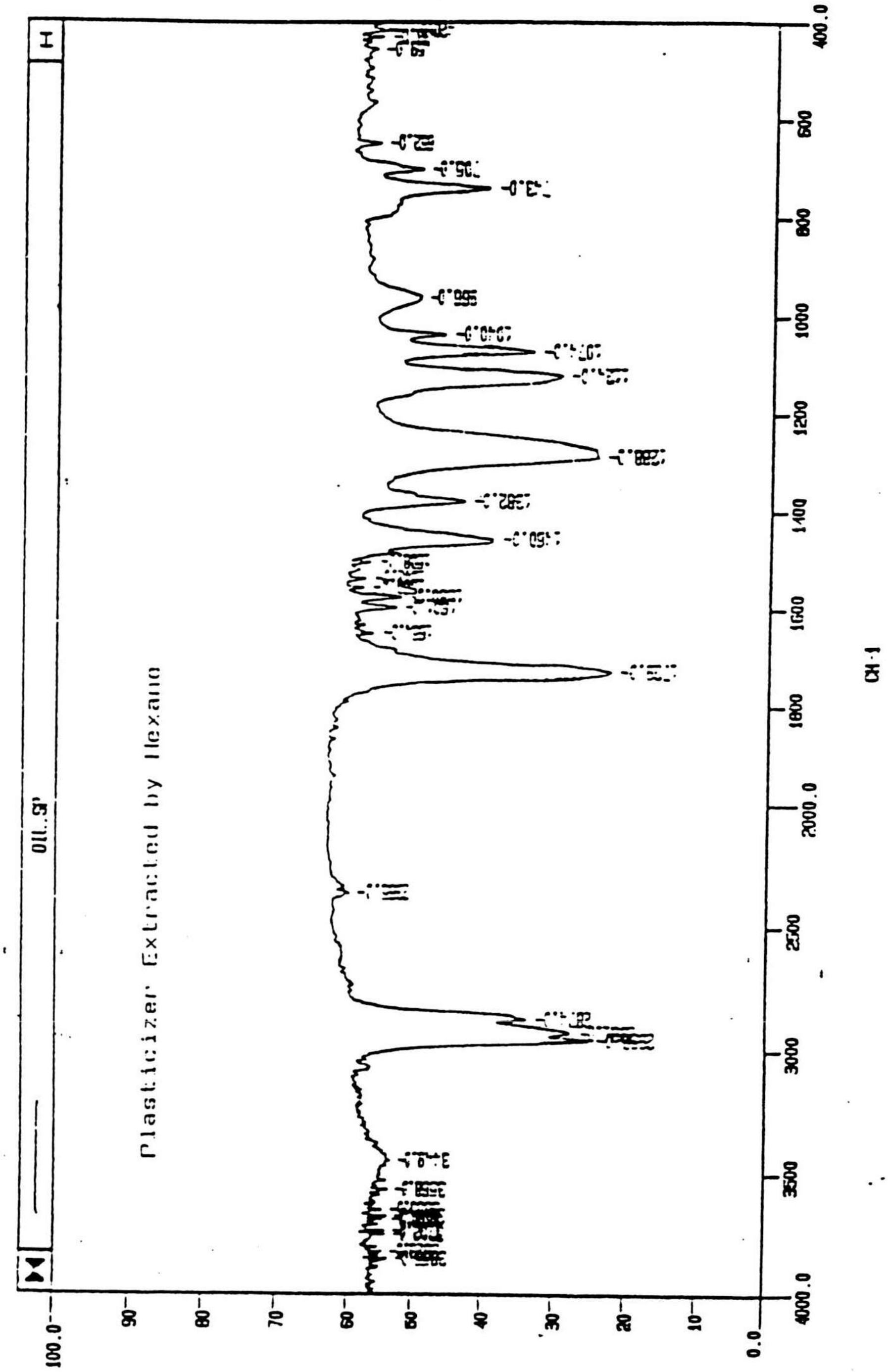

Fig 4.34: FTIR spectra of plasticizer in hexane, .

From all of the results in Section 4.5 on Oil Resistance Test, oil resistance of plasticized PVC with and without NBR was evaluated by using three petrol reagents. The result can be concluded that:

For plasticized PVC without NBR, the magnitude of the effect of the three petrol reagents to all mechanical properties can be summarized in the following order:-

Hexane> Unleaded Gasoline> Motor Oil

This result is in the good agreement with those in weight change as describe in section 4.5.2.1.

For plasticized PVC with the presence of NBR, different results in the magnitude of the effect of the three petrol reagents was found. The motor oil has the most effect on the moduli properties and hexane has a greater effect than unleaded gasoline.

From the oil resistance test in three petrol reagents, it can be concluded that the resistance of NBR with plasticized PVC to unleaded gasoline is the highest and that to the motor oil is the lowest.

The poor resistance of NBR to motor oil causes very little effect to the weight change even when the NBR content was increased.

Although the formulation of the plasticized PVC in this study is a general purpose one, the experimental results do depict the trend that several properties of plasticized PVC will change by an addition of NBR. The improve in the resistance of the plasticized PVC with NBR to unleaded gasoline and hexane means that there is possibility of using the plasticized PVC with NBR in automotive parts which are likely to be in contact either intermittently or constantly with unleaded gasoline. A typical example of such application is the automotive gasoline hose.

4.6 Fractography

The morphology of NBR investigated by using a Scanning Electron Microscope (SEM) shows the rubber as agglomerates consisting of several small spherical particles as shown in Fig 4.35.

Fig 4.35: Electron micro-photograph shows NBR as agglomerates of several NBR spherical particles.

Fig 4.36 shows the only one of the NBR agglomerate found from all of the fractured surfaces of plasticized PVC with NBR observed microscopically by the SEM.

Fig 4.36: Electron micro-photograph shows the rarely found NBR agglomerate in plasticized PVC with addition of 40 phr NBR.

NBR particles are very rarely observed on the surface regardless of the NBR content. The lack of the appearance of NBR particles obviously verifies the miscibility between the plasticized PVC and the NBR particles, as was proved thermally by the DSC thermalscans.

Fig 4.37 shows the calcium carbonate which was applied as a filler in the plasticized PVC formulation in the present work. Calcium carbonate particles can be observed microscopically. It is of various sizes and has different crystallographic shapes.

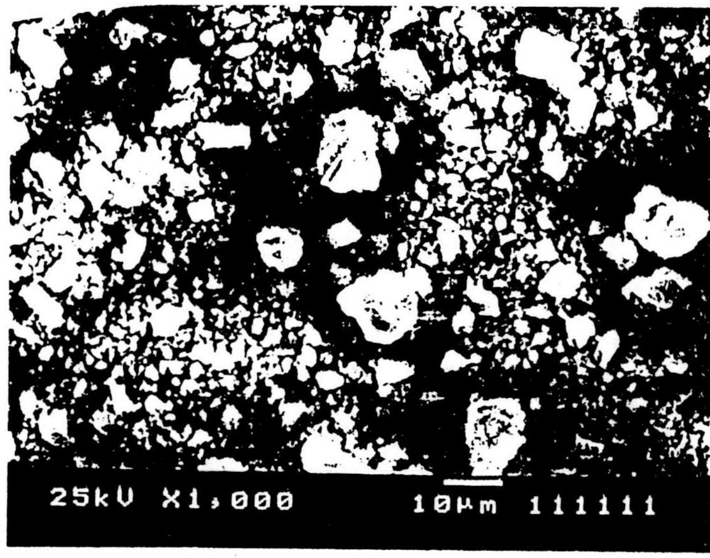

Fig 4.37: Electron micro-photograph shows the calcium carbonate used in this present study.

Fig 4.38 shows the calcium carbonate particles in the plasticized PVC without any NBR.

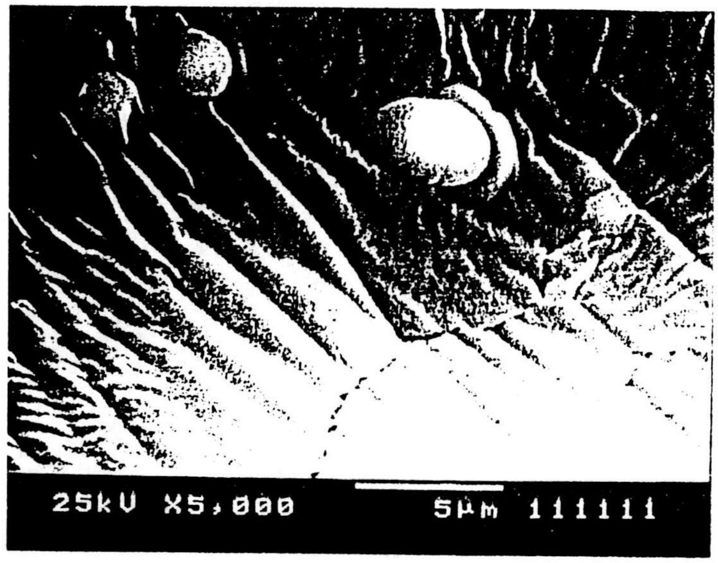

Fig 4.38: Electron micro-graph shows the fracture surface of plasticized PVC. The spherical particles are calcium carbonate.

In general, calcium carbonate possesses certain crystalline structure. In this particular study, calcium carbonate is observed as elliptical or spherical shape. The change in the shape of calcium carbonate is believed to be induced by the intense shear stress during processing. In addition, the hydrochloric acid given off during the heating step of the plasticized PVC production may have partially reacted with the calcium carbonate. Consequently, calcium carbonate tends to loose its original crystalline form and exhibits a more rounded or elliptical shape.