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High Performance Oil Resistance in Nitrile Rubbers

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Abstract

Natural rubber is prone to have less resistance to chemical attack, UV, Ozone, Flame and Oils. Many researches have been carried out using various techniques in order to improve the physical properties of rubber. For example, Aging resistance of Natural rubber is improved by introducing nanoAl_2O_3 particles into Natural rubber [2013]. Modification of Natural rubber as a resistant material to Dimethyl ether [2017]. Study of Aging resistance properties of Natural rubber dried by Microwave [2013]. High performance oil resistant rubbers [2012] were carried out by blending NBR,CR/PVC-Swelling in toluene.

I. INTRODUCTION

In the present work, the study of various oils namely coconut oil, linseed oil, hydraulic oil, sunflower oil, cotton seed oil, palm oil have been tested with compatibility of Nitrile and Natural rubber. This has been achieved through blending with Nitrile rubber and PVC as Plasticizer. Among the different Oil formulations, the compatibility is good with Cotton seed oil, the swelling percentage is less than 40%. Other resistance namely Flame resistance, Ozone resistance, Aging property, Hardness, Tensile strength and Elongation has been improved. This study showed that NBR/PVC blends are characterized with high performance oil resistant, which can be recommended to automotive industry.

II. EXPERIMENTAL WORK

Materials

- Acrylonitrile butadiene rubber (NBR, Perbunan 3310, Bayer AG, Germany), with acrylonitrile content of 36±1%, density 0.89 g/cm3 and Moony viscosity ML 4 (100 °C) of 75±6.
- Chloroprene rubber (CR, Baypren 110, Bayer AG, Germany, with Moony viscosity ML 4 (100 °C) of 50-60, density1.33 g/cm3.
- Polyvinylchloride (PVC, Sabic, Saudi Arabia) powder, suspension grade, with a K-value of 55 and degree of polymerization 950-1090.
- High abrasion furnace black N330 (Carbon company, Egypt) with a density of 1.56-1.72, a pH value of 8-9, average particle size of 38nm
- Dioctylephthalate (DOP), sulphur, N-cyclohexyl-2-benzothiazole sulphonamide (CBS), N-isopropel-N-phenyl-p- phenylenediamine (IPPD), zinc oxide (ZnO), magnesium oxide (MgO), ethylene thiourea (ETU) and stearic acid were obtained from local rubber enterprises.

The parameters that were analysed in the present study are

- Elastomer blends
- Compounding Ingredients
- Testing- Hardness, Elongation and Tensile strength
- Filler selection
- Accelerators
- Activators
- Various oils for compatibility [Cotton seed oil , Palm oil, Sunflower oil, Linseed oil, Hydraulic oil]

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Table-I

INGREDIENTS **PARTS PER HUNDRED RUBBER**	**FORMULATION I**	**FORMULATION II**	**FORMULATION III**	**FORMULATION IV**	**FORMULATION V**	**FORMULATION VI**	**FORMULATION VII**	**FORMULATION VIII**
Nitrile	-	-	60	60	60	60	60	60
Natural	100	100	40	40	40	40	40	40
Zinc oxide	5	5	8	8	8	8	8	8
Stearic acid	1	1	1	1	1	1	1	1
Precipitated calcium carbonate	50	50	50	50	50	50	50	50
Aluminium silicate	20	20	20	20	20	20	20	20
HAF carbon	30	30	30	30	30	30	30	30
Sulphur	1.8	1.8	1.8	1.8	1.8	1.8	1.8	1.8
GPF carbon	20	20	20	20	20	20	20	20
Process oil (Aromatic)	20	20	5	5	5	5	5	5
MBTS	1.5	1.5	1.5	1.5	1.5	1.5	1.5	1.5
TMTD	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.5
Paraffin wax	1	1	1	1	1	1	1	1
TDQ / HS	1	1	1	1	1	1	1	1
ZC/ Pilflex 100	1	1	1	1	1	1	1	1
Cotton Seed Oil-III &IV Palm oil- V Linseed oil- VI Sunflower oil- VII Hydraulic oil- VIII	-	-	15	15	15	15	15	15
PVC-IV,V,VI,VII and VIII	-	-	-	20	20	20	20	20

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Table-II

Mechanical properties of the investigated formulation					
Property / No. of samples	**1**	**2**	**3**	**4**	**5**
Modulus at 100% (MPa)	1.81	3.12	2.01	2.57	2.21
Tensile strength (MPa)	15.95	21.67	18.74	24.46	25.7
Elongation at break (%)	566	445	475	380	410
Young‘s modulus (MPa)	1.58	1.64	1.69	2.21	1.59
Hardness (shore A)	75	79.5	80	84	81
Strain energy MJ/m3	1.052	2.08	0.554	2.11	2.232

III. MOULDING & DEFLASHING

The four compounds were verified for mould ability, the moulded parameters and the deflashing feasibility are as follows:

PARAMETERS	**I**	**II**	**III**	**IV**
TEMPERATURE	150^0C	160^0C	155^0C	165^0C
PRESSURE	1.5 TON	1.5 TON	1.5 TON	1.5 TON
TIME	5 MINS	5 MINS	5 MINS	5 MINS
PRODUCT ASTHETIC	GOOD	GOOD	GOOD	GOOD
DEFLASHING	GOOD	GOOD	GOOD	GOOD

IV. RESULTS AND DISCUSSION

S. No	**PARAMETERS TESTED**	**FORMULA I**	**FORMULA II**	**FORMULA III**	**FORMULA IV**	**FORMULA V**
1	SHORE A HARDNESS	65	65	65	65	65
2	TENSILE STRENGTH KG/CM²	140	85	100	80	80
3	ELONGATION @ BREAK %	800	600	450	380	380
4	COMPRESSION SET %	15	25	18	20	20
5	HEAT AGEING 70° C FOR 72 HRS	--	--	--	GOOD	GOOD
a.	CHANGE IN HARDNESS	2	2	2	2	2

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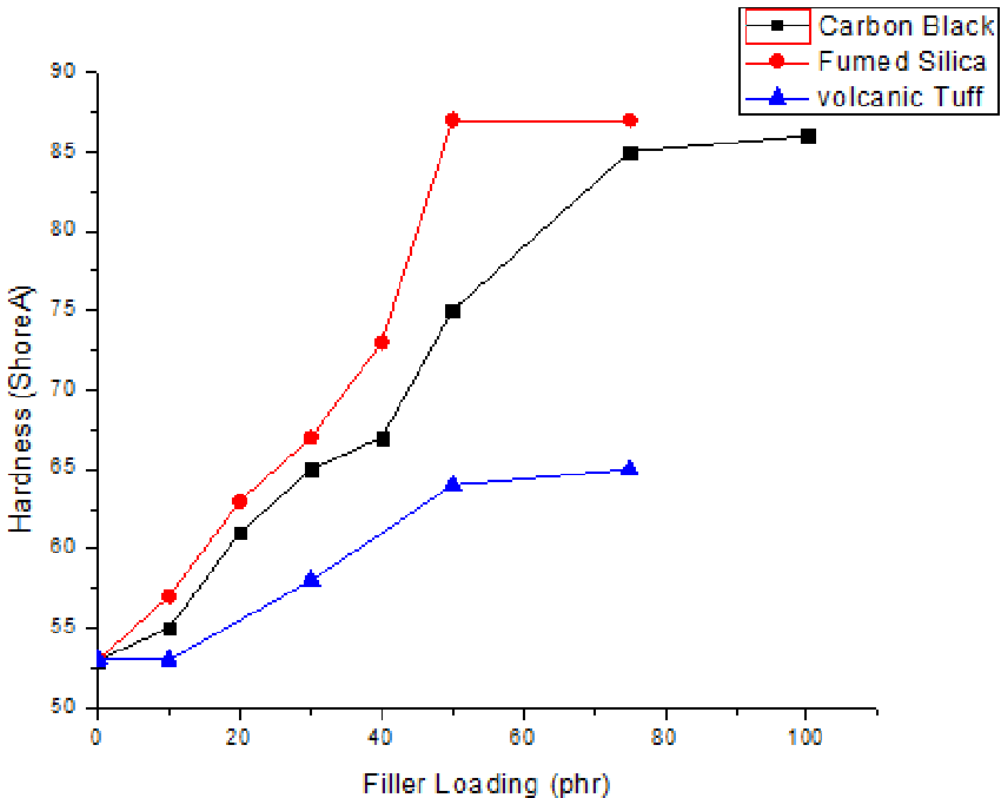
b.	CHANGE IN TENSILE STRENGTH	-15	-10	-13	-10	-10
c.	CHANGE IN ELONGATION AT BREAK	-30	-25	-28	-25	-25
6	SWELLING IN ASTM 3 OIL 70° C FOR 72 HRS	92	2.5	24	8	8
7	SWELLING IN PETROL FOR 72 HRS	112	13	38	28	28
8	SPECIFIC GRAVITY	1.35	1.33	1.30	1.30	1.30
9	COST OF FORMULATION PER KG	100	175	120	135	135
10	FLAME RESISTANCE	NO FLAME RESISITANCE	NO FLAME RESISTANCE	NO FLAME RESISITANCE	FLAME RESISITANCE	FLAME RESISITANCE

FORMULA VI : Sunflower oil was also not compactable with nitrile rubber.

FORMULA VII : Linseed oil was also not compactable with nitrile rubber.

FORMULA VIII : Hydraulic oil was also not compactable with nitrile rubber.



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- **SHORE A HARDNESS :**As all the recipes has same parts of filler contents the hardness remains same for all the four formulations.
- **Tensile Strength :** For natural rubber the green strength is comparatively high than nitrile, PVC, there by the tensile is maximum for the natural rubber, Nitrile rubber has poor green strength than the natural but higher than the PVC,blends of nitrile and the natural has moderate strength.
- **Elongation at Break:** Elongation of natural rubber is much higher when compared to that of nitrile , PVC, and blends as the elastic nature of the natural rubber is best and the PVC is poor due to the plasticity & moderate for nitrile and natural blend.
- **Compression Set :**Compression set of the nitrile is poor when compared to that of natural and the blends as the renounce property of the natural is best and the PVC is poor as the blends contain the natural 40 parts they have moderate compression set.
- **Heat Ageing :** Both the nitrile and the nitrile blended with the PVC has better heat ageing properties than that of natural rubber as the natural rubber is naturally weak to ozone and oxidation when compared to that of nitrile and the polyvinyl chloride.
- **Oil Resistance :** Nitrile rubber is generally resisitance to oil as the acryl group is present in its structure and the natural is poor to oil resistance there by the blends also shows moderate oil resistance when compared to that of pure nitrile rubber composition and the fourth formulation has the polyvinyl chloride which is good in oil resistance.
- **Petrol Resistance :** Nitrile Rubber is generally good resistance to fuel resistance due to the presence of acryl content were the natural rubber is poor resistance to the fuel, the blends also shows the moderate impact to that of petrol as they contain the 40 parts natural but the fourth formulation contains 20 parts of polyvinyl chloride there by it shows better resistance when compared to that third formulation.
- **Specific Gravity :** As all the formulation contain the same parts of filler and a minor difference in the polymer density the specific gravity of all the composition remains the same.
- **Impact of Cost :**As described in the tabulation the cost of the nitrile rubber is highest with good oil resistance the blends are moderate in cost with required oil resistance and the natural is cheap but with no oil resistance.
- **Flame Resistance :** PVC composition shows the flame resistance as the chlorine content is present In the fourth formula as well as the chlorinated paraffin wax is being mixed in that formula, where the remaining composition one, two and three are poor in the flame resistance as they do not possess any halogen groups in their composition.

V. CONCLUSION

1. This blend has the swelling character better than the pure natural polymer but poor than that of pure nitrile polymer.
2. The project has concluded with the positive result that the blending of polymers with cotton seed oil and palm oil gave less swelling percentage (i.e., less than 40 %)
3. PVC combination has the additional character of fire resistance and good ozone resistance.
4. Thereby we can conclude that the ***Fourth formula*** and ***Fifth formula (***Nitrile Polymer , PVC , Chlorinated Paraffin wax , Cotton seed oil & Palm oil, Natural rubber with aluminium silicate and precipitated calcium carbonate as filler) has better output.

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The above formulation is being suggested for the cost saving with required quality as specified by the organization

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