Experimental Investigation on Compatibility of Elastomeric Materials with Biodiesel

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Abstract: **The world is presently confronted with the twin crises of fossil fuel depletion and environmental degradation. As such, the situation demands for an alternate source of energy that can be used to overcome the forecasted future energy crisis. Biodiesel is proved to be the best replacement for diesel. Even though the biodiesel is considered as a better fuel than the fossil fuel, the automobile sector is not ready to accept biodiesel because of less research related to compatibility of materials with the biodiesel. This lags in the implementation of completely biodiesel engine in automobiles. This paper investigates the effect of biodiesel on elastomeric materials used in IC engine and to suggest suitable elastomeric material which is having higher compatibility with the biodiesel fuel. The the elastomeric materials like NBR, CR, EPDM, Silicone and Natural Rubber are immersed into the biodiesel and evaluating mechanical behaviors immersed at 750hrs. The experiments shows that the suitability of elastomers for biodiesel is NBR > CR > EPDM > Silicone > Natural rubber.**

Key words: **WCO biodiesel, Elastomers, NBR, CR, EPDM, Silicone, Natural rubber, immersion tests.**

I. INTRODUCTION:

The issues of fossil fuel depletion and environmental degradation are driving the search for the alternative fuels. One such fuel is biodiesel, another option to diesel fuel created by transesterification of vegetable oils or animal fats. It offers property near that of diesel fuel and has no sulfur and no aromatics. In diesel engine, fuel comes into contact with a wide assortment of materials. Material compatibility in biodiesel may not be quite the same as that in diesel. Diesel is a blend of hydrocarbons, while biodiesel is a blend of unsaturated fat esters. The similarity of seal, gaskets, hose materials ordinarily utilized as a part of car fuel frameworks utilizing regular diesel fuel has for quite some time been set up.

Elastomers are essentially complex blend of polar and non-polar substances including polymers, fillers, oil, plasticizer, stabilizers, curing operators, cell reinforcements, antizonants and preparing helps. When it is submerged in a dissolvable, the elastomer lattice tends to swell. Swelling of EPDM, SR, CR and NBR upon presentation to fuel can be ascribed to the assimilation of dissolvable and unwinding of polymer chains.

Be that as it may, there is substantially less data accessible on the similarity of fuel framework elastomers with biodiesel especially Waste Cooked Oil (WCO) biodiesel. It has been accounted for that degradation of specific elastomers is one of the principle issues identified with material compatibility in biodiesel. From the literature it is clear that the impact of methyl yester and diesel blends on the elasticity, lengthening, hardness, and swelling of a few basic elastomers demonstrates different outcomes in view of their exploratory strategies. As the material will more exposure with fuel leads to higher swell because of the extraction of soluble components of elastomer.

Irrespective of such impacts, a restricted however unequivocal part is generally ascribed to describe the similarity of various elastomers in biodiesel. The present examination plans to research the effect of Waste Cooked Oil (WCO) biodiesel on the degradation value of Nitrile Rubber (NBR), Chloroprene Rubber (CR), EPDM, Silicone Rubber and Natural Rubber and to propose the perfect material among them.

II. EXPERIMENTAL SET UP:

The compatibility of various elastomeric materials viz, Nitrile Rubber (NBR), Chloroprene Rubber (CBR), EPDM, Silicone and Natural Rubber with Waste Cooked Oil (WCO) biodiesel was evaluated by conducting immersion in B0 (diesel), B20 (20% biodiesel in diesel), B50 (half biodiesel in diesel), B100 (biodiesel) at room temperature (32 0C) for 250 h.

At the end of immersion, degradation of various elastomers was portrayed by estimating changes in weight, volume, hardness and elongation. Changes in weight were estimated by adjust with 3 decimal accuracy. The hardness estimation of the materials was meausred utilizing "Shore A" Hardness analyzer. All these tests were conducted before and after immersion test.

III. RESULTS AND DISCUSSION:

A. % Changes in Volume:

Fig. 1 demonstrates the change in Volume of the elastomers upon exposure with various blends of biodiesel with diesel fuel. Volume for Nitrile Rubber (NBR), Chloroprene Rubber (CR) and Natural Rubber increases with expanding the concentration of biodiesel, while for EPDM and Silicone Rubber displays reduced volume with increments in biodiesel concentration.

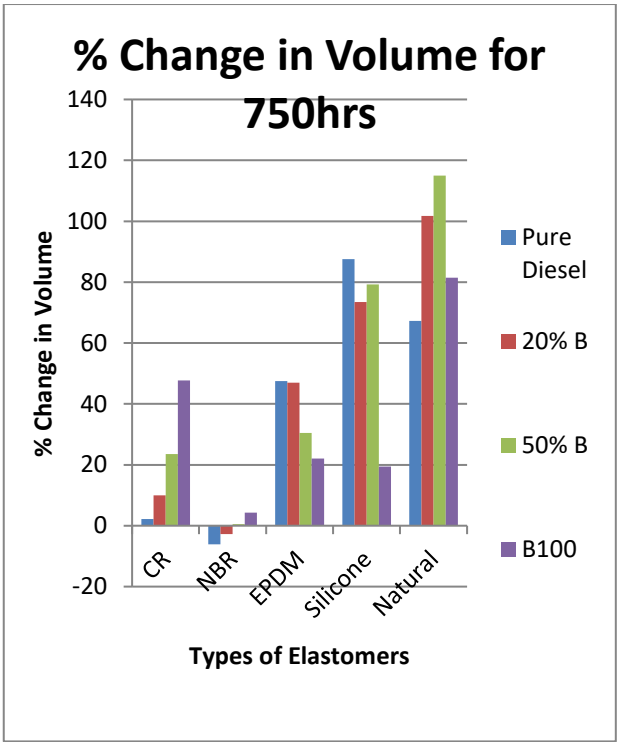

Figure 1. Change in Volume of elastomer for different biodiesel blends for 750hrs.

Elastomers appear to swell in biodiesel through responses with the polymer backbone and cross-linking framework, or by responses with the filler system. This results that biodiesel and its blends cause a grater swelling of CR, NBR and Natural rubber contrasted and that caused by diesel. Then again, EPDM and Silicone swelled to a more noteworthy degree in diesel contrasted and that in biodiesel and its blends.

NBR is a complex group of unsaturated copolymers of ACN and butadiene while CR alludes to polymers of 2-chloro-1,3-butadiene with one polymerizable monomers. The more noteworthy the acrylonitrile content in NBR, the less the swell in fuels as it can guarantee expanded cross-linking in the polymer spine [1].

The principle behind the swell of the elastomer is "like – disintegrates - like." There is a general rule depicting the way that polar substances will probably break down in polar solvents and nonpolar substances will probably break up in non-polar solvents [2]. For polar dissolvable, the positive ends of the molecules will draw in the negative ends of the solute atoms and accordingly makes an intermolecular power known as dipo - leedipole association. The level of dipo - leedipole cooperation in biodiesel for solute is by all accounts higher when contrasted with that in diesel in light of its extra exceptional synthetic distinction emerging from the expanded extremity of esters [4]. Subsequently, swelling of same elastomer material is similarly higher in biodiesel than that in diesel fuel. In the event that the dissolvable polymer collaborations are more predominant than polymer connections, greatest swelling can be obtained [3].

B. % Changes in weight:

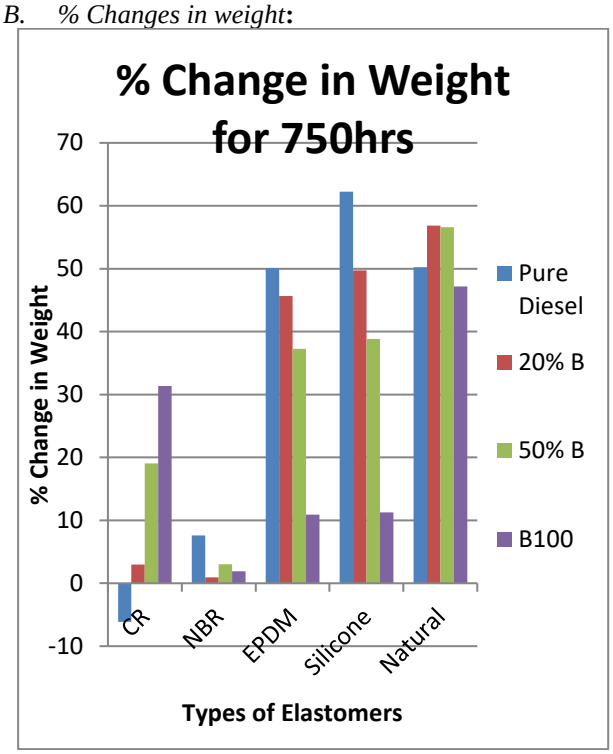

Figure 2. Change in Volume of elastomer for different biodiesel blends for 750hrs.

It is seen that the as changes in weight for both CR and NBR are higher in biodiesel when differ strikingly with that in diesel. Then again, EPDM, SR and Natural Rubber are less perfect with biodiesel. This can be attributed to the higher extremity of ester segments in biodiesel which enables the more polar elastomers to disintegrate to dissolve to a greater extent.

Moreover, all particles additionally have weak intermolecular forces called London Dispersion forces by which positive cores of the solute molecule atoms will pull in the negative electrons of the dissolvable atom molecules [2]. This gives the non-polar dissolvable more noteworthy capacity to solvate the solute particles. The increase in weight came about as the degree of more liquid absorption when contrasted with the extraction solvent segments from elastomer. The expansion in weight can be ascribed to the degree of higher fluid assimilation when contrasted with the extraction of dissolvable segments from elastomer. Then again, the causes of lightly reduced weight for CR and NBR can be attributed to the absorption of lighter component like diesel or biodiesel and in the meantime, disintegration of dissolvable parts, for example, plasticizers, stabilizers or added substances from the elastomers [1].

C. % Changes in Elongation:

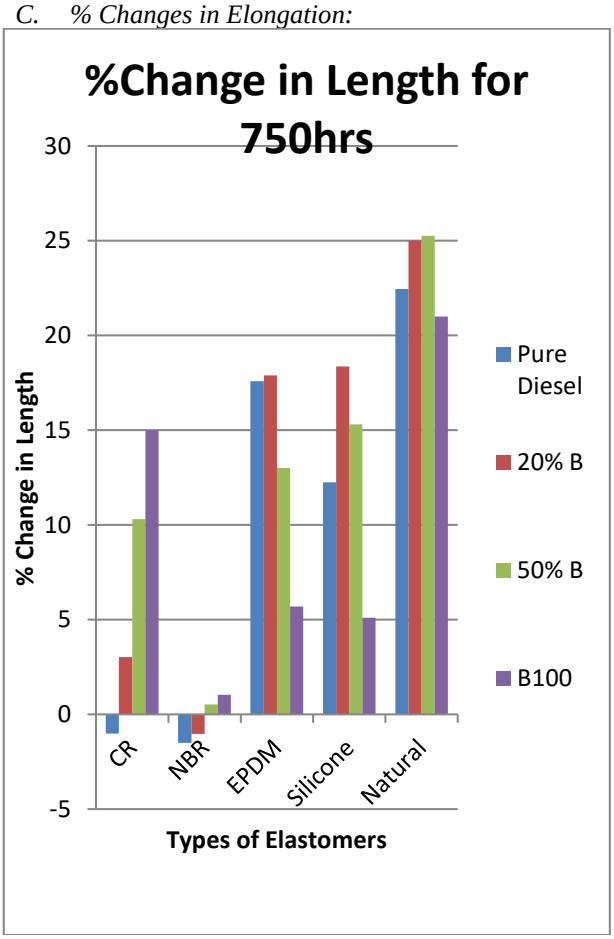

Figure 3. Change in Length of elastomer for different biodiesel blends for 750hrs.

Figure 3.demonstrates the changes in Elongation of the elastomers upon immense in various biodiesel and their blends. Elongation for Nitrile elastic (NBR) and Chloroprene Rubber (CR) increased with concentration of biodiesel and displays lessened length if there should arise an occurrence of diesel. While for EPDM and Silicone Rubber displays diminish in elongation with increments in biodiesel concentration while Natural Rubber shows higher stretching for B20 and B50 blends and bring down extension for pure biodiesel contrasted and diesel. Notwithstanding, higher change in length was seen in case of biodiesel.This maybe because of higher absorption of biodiesel in elastomer.

D. % Changes in Hardness (Shore A):

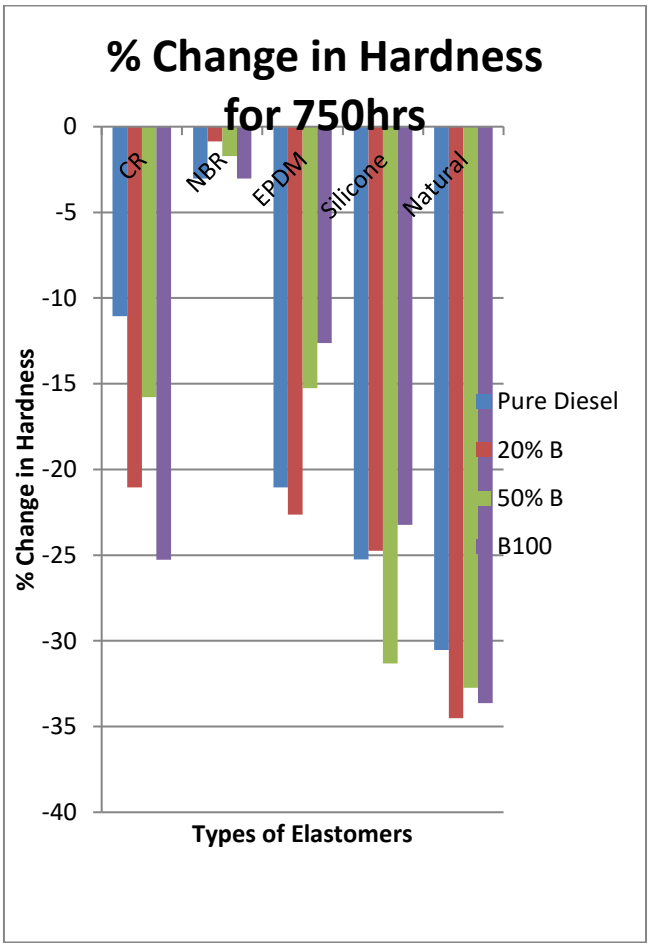

Figure 4. Change in Hardness of elastomer for different biodiesel blends for 750hrs.

From the figure 4 it is clear that the shore A hardness value of elastomeric materials will diminishes when presented to biodiesel. Likewise hardness of CR and NBR in biodiesel diminishes more contrasted with that for diesel, though the hardness value for EPDM, Silicone and Natural Rubber shows higher than that of the diesel. This may demonstrate higher disappearing of crosslinking for Chloroprene Rubber (CR) after immersion into biodiesel.

For elastomers, carbon dark & silica fillers can serve to enhance the hardness. The expansion of curing specialists and quickening agents cause cross-connecting between the polymer chains or spine. It is this system that cross-connects to a great extent, decides these physical properties. Upon exposure of various elastomers into biodiesel, these cross-connecting agents or filler appear to respond with components of biodiesel and accordingly fall apart the physical & mechanical properties.
Not at all like NBR and CR; EPDM and Silicone does not demonstrate any critical auxiliary change upon exposure to biodiesel. All representing functional groups remain intact even after long immersion into biodiesel.

E. % Changes in Volume for 250hrs and 750hrs:

From fig 5, it can be view that as the immersion days are increased the percentage change in volume of elastomers will decreases, because in initial time interval the elastomer molecules will react with biodiesel very rapidly and as a time permits the molecules reach saturation points and reduces in percentage change.

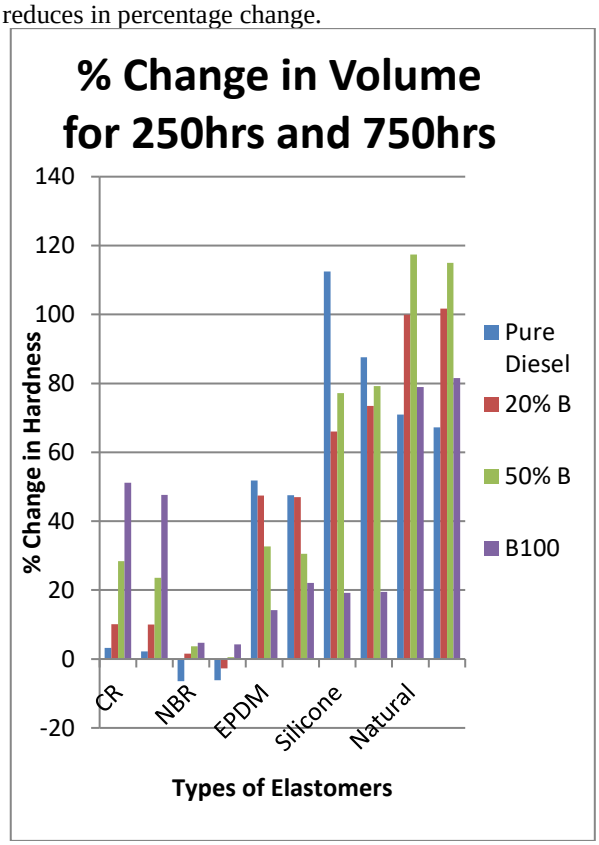

Figure 5. Change in volume of elastomer for different biodiesel blends for 250hrs and 750hrs.

IV. CONCLUSIONS:

The accompanying conclusions can be drawn from this investigation as

1. The weight and volume for NBR, CR and Natural Rubber are expanded with increasing the concentration of biodiesel while for EPDM and Silicone Rubber they diminish with biodiesel concentration.
2. After immersion into biodiesel it is found that the elongation and hardness were significantly reduced for both EPDM and silicone while negligible changes were found for Natural Rubber, though CR and NBR demonstrates unfavorable with these materials.
3. Biodiesel containing ester has more carboxylic gatherings when contrasted with those in petrodiesel. Elastomers are appeared to be debased more by those carboxylic polar groups of biodiesel.
4. The obtained results from this work can assure consumer that the compatibility of elastomers for biodiesel is in the preference like NBR > CR > EPDM > Silicone > Natural rubber.

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