CHAPTER III

LITERATURE REVIEWS

B. Jones, et al [8] compared the effects of E20 versus E10 and gasoline on plastic materials found in automotive and small engine fuel system components. They studied the materials commonly used in flex-fuel vehicle fuel systems, that are acrylonitrile butadiene styrene (ABS), nylon 6 (PA6), nylon 6,6 (PA6,6), polybutylene terephthalate (PBT), polyethylene terephthalate (PET), polyetherimide 1010 moldable (PEI), polyurethane (PUR) and polyvinyl chloride flexible version (PVC). Plastic samples were prepared according to SAE and ASTM standard and exposed to surrogate Fuel C (gasoline), gasohol E10 and E20 at an elevated temperature of 55 °C for 3024 hours (Note: surrogate Fuel C is : blending between isooctane and toluene). Each fuel was changed in weekly intervals for the 18-week study. Physical and mechanical properties were measured before immersion and compared to the values recorded after the soak process.

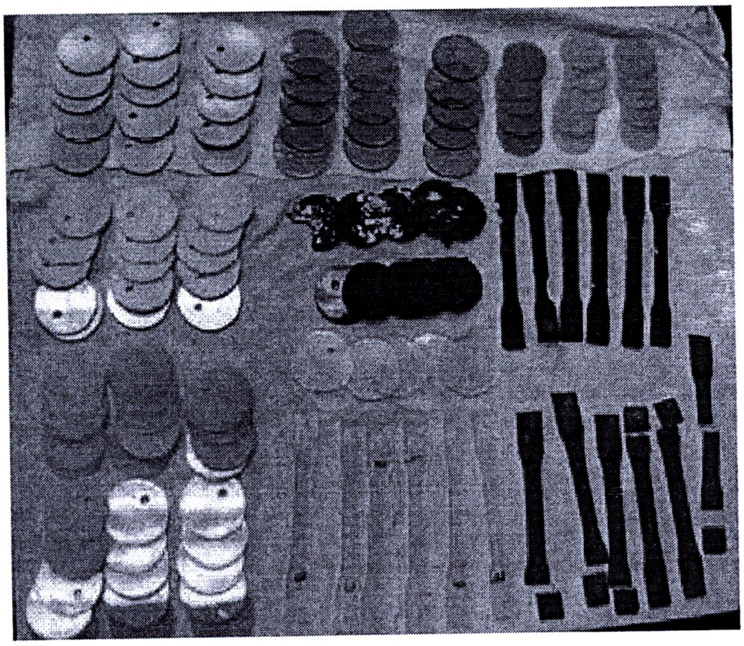

Figure 3.1 Samples used in study of B. Jone, et al [8]

The results showed that four of the materials, PA6, PA66, PET and PEI were compatible with the three fuels. The change of properties of these four materials, such as mass, volume, tensile strength, tensile elongation and impact resistance were small for samples immersed in any of the three fuels. While the other four materials, ABS, PUR, PVC and PBT were affected by all three fuels to varying degrees. Those ABS specimens were turned to a jelly-like mass in the bottom of the jars after less than one week. PVC demonstrated significant changes in mass and volume in all three fuels but to a higher degree in ethanol fuels. The PBT data also showed impact resistance increased in all three fuels but to a greater extent in the ethanol blends. The PUR was cracked and showed changes in mass, volume, tensile strength, and elongation. The mechanical properties of plastics were shown in Figure 3.2 and Figure 3.3.

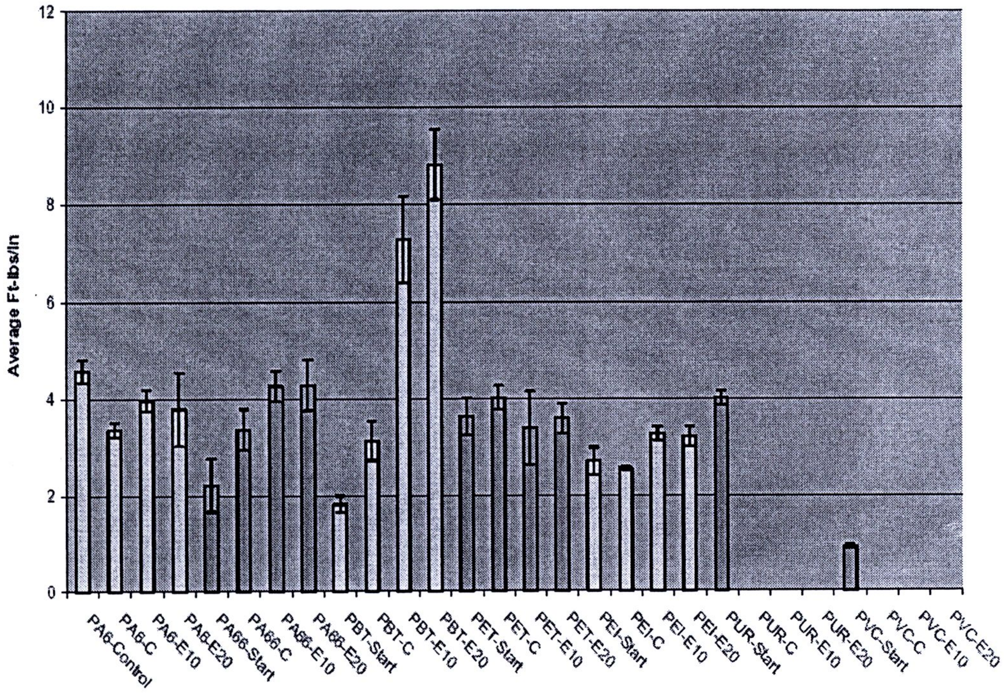

Figure 3.2 Izod impact strength of plastic samples in three test fuels [8]

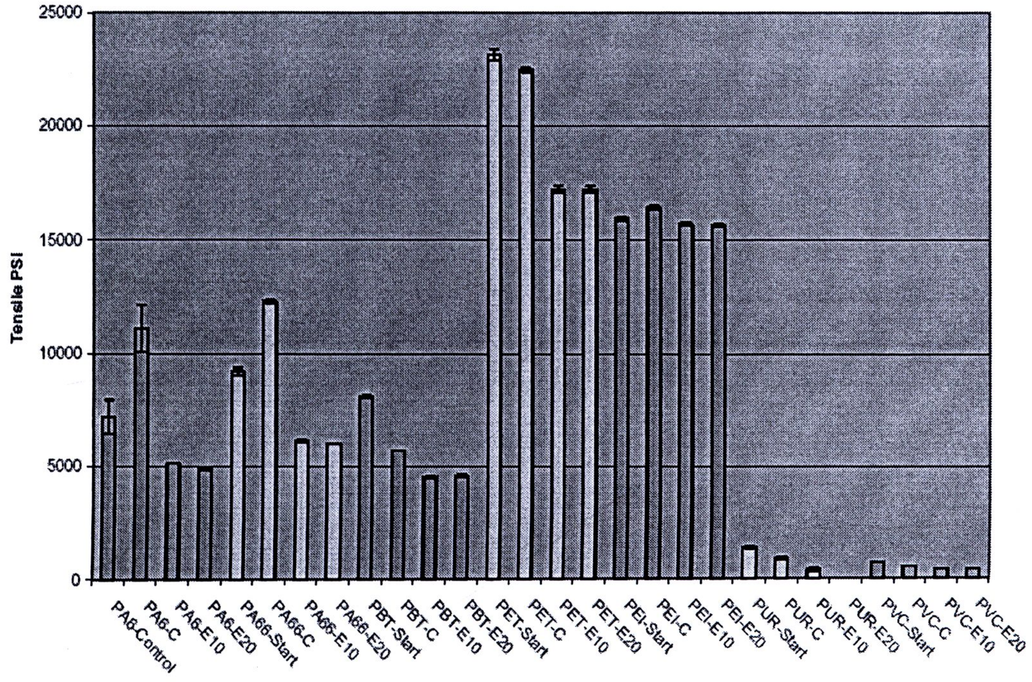

Figure 3.3 Tensile strength of plastic samples in three test fuels [8]

A. Gullu, et al [11] in 2004 investigated the influence of fiber reinforcement and injection parameters on mechanical properties of polypropylene (PP) and polyamide 6 (PA6) plastics. The plastics were reinforced with (15 and 30 wt%) silane coated glass fibers. Each test specimen was prepared by injection molding machines, where the injection parameters were controlled precisely by a computer. The results indicated that 15 wt% and 30 wt% fiber reinforcement for PP can improved the tensile strength of PP by 128% and 199%, respectively. Similarly, the same amounts of reinforcements improved the tensile strength of PA6 by 74% and 111%, respectively. But it dose not always increase impact energy when fiber content increases because fiber fractures also increase as, shown in Table 3.1

Table 3.1 The influence of the fiber content on the mechanical properties of the composite material [11]

Material	Izod impact strength (kJ/m^2)	Tensile strength (MPa)	Strain at break (%)
PA6, unreinforced	10.98	64.70	51.53
PA6, 15 wt% fiber reinforced	8.575	112.38	8.83
PA6, 30 wt% fiber reinforced	11.98	136.61	8.18
PP, unreinforced	11.24	26.26	700
PP, 15 wt% fiber reinforced	10.7	60.04	8.15
PP, 30 wt% fiber reinforced	12.8	78.61	11.05

Table 3.2 showed tensile strength decreased and impact energy increased with increasing injection screw speed. Furthermore, the result showed that by increasing injection speed, fiber fractures increased and fibers were oriented perpendicularly to the flow direction.

Table 3.2 The influence of screw speed on the mechanical properties of the composites material [11]

Material	Screw speed (rev/min)	Izod impact strength (kJ/m^2)	Tensile strength (MPa)	Strain at break (%)
15 wt% fiber reinforced				
PA6	100	8.57	112.38	8.83
PA6	150	10.65	107.65	8.50
PP	100	10.70	60.04	8.15
PP	150	11.10	52.28	8.39
30 wt% fiber reinforced				
PA6	100	11.98	136.61	8.18
PA6	150	13.10	129.26	9.01
PP	100	12.82	78.61	11.05
PP	150	14.70	70.50	11.20

P. Chooseng [9] in 2009 investigated the effects of glass fiber content and the effects of ethanol concentration in gasohol on physical and mechanical properties of neat PA6 and PA6 compound with 15 wt% and 30 wt% glass fiber. For this purpose, each polyamide 6 composite specimen was prepared by compression and injection molding machines.

Figure 3.4 Test containers [9]

These specimens were immersed in 4 different test fuels, namely, $C(E0)_A$, $C(E20)_A$, $C(E85)_A$, and $C(E100)_A$ at room temperature. Where $C(E0)_A$ is pure surrogate Fuel C . The soaking apparatus was shown in Figure 3.4. The results indicated that the PA6 matrix had an excellent adhesion to glass fiber reinforcement. The glass fiber could improve the mechanical properties of the composites and dimensional stability of specimens by reducing amorphous region while increasing crystalline region. Figure 3.5 showed that Young's modulus of unsoaked test materials increased with increasing fiber content.

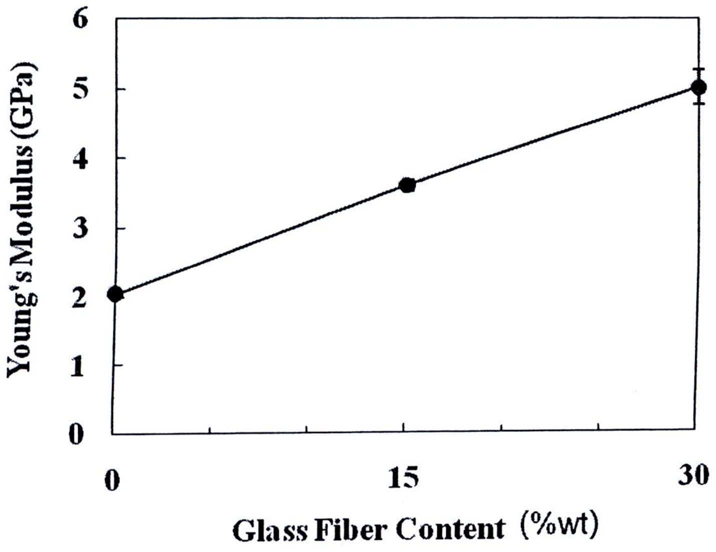

Figure 3.5 Young's modulus of unsoaked PA6/GF composites [9]

Test fuels containing alcohol, i.e. C(E20)$_A$, CE(85)$_A$ and C(E100)$_A$ affected the tensile strength, flexural strength and Young's modulus of both unreinforced and reinforced PA6 composites more than C(E0)$_A$ due to adsorption of water and alcohols from C(E20)$_A$, CE(85)$_A$ and C(E100)$_A$ by both unreinforced and reinforced PA6 composites. Figure 3.6 showed that, after long enough immersion time, the Young's modulus of three test materials soaked in test fuels containing alcohol decreased to the same value and decreased more than specimens soaked in surrogate gasoline.

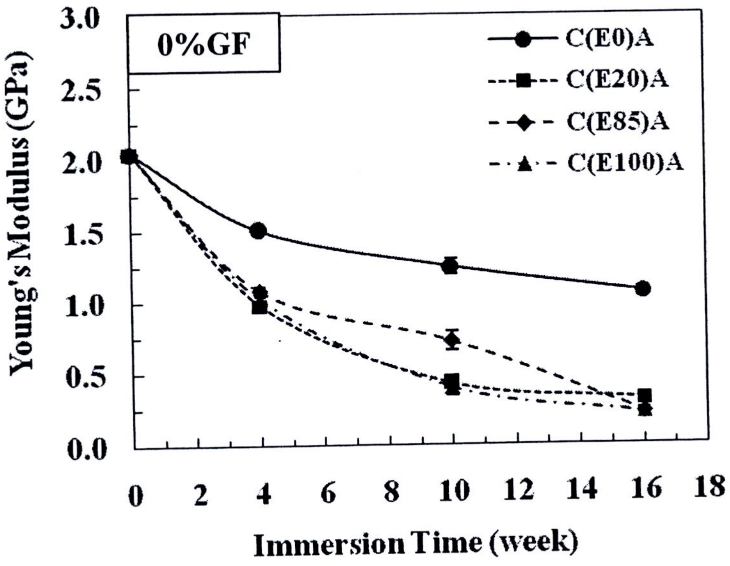

Figure 3.6 Young's modulus of PA6 immersed in test fuels [9]

D.P.N. Vlasveld, et al. [56] in 2007 studied the flexural and compressive strengths of PA6 nanocomposite reinforced with woven glass fiber at various temperature and after moisture conditioning. The strength of neat PA6 fiber composites was studied over a wide temperature range and after moisture conditioning to indicate the influence of the temperature and absorbed moisture on the strength of the composite.

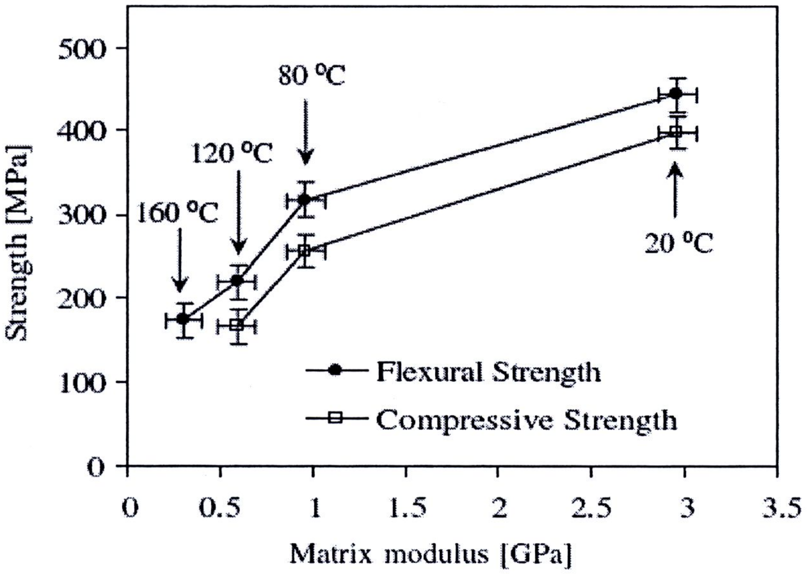

Figure 3.7 Flexural and compressive strengths of dry PA6 glass fiber composite as function of the matrix modulus (neat PA6) [56]

The result showed that flexural and compressive strength decreased with increasing temperature and the fast decrease of flexural and compressive strength around the T_g of the matrix polymer, around 65 °C for PA6, shows a correlation with the composite modulus. Influence of fiber content in polymer matrix showed the flexural strength with nanocomposite at 120 °C is similar to the flexural strength with a PA6 at 80 °C and at 160 °C the flexural strength is even higher than at 120 °C with the unfilled PA6 while the compressive strength with a nanocomposite at 120 °C is similar to the strength with a PA6 at 90 C (per interpolation). Therefore, with this nanocomposite it is possible to increase the useful temperature range for PA6 with 30-50 °C.

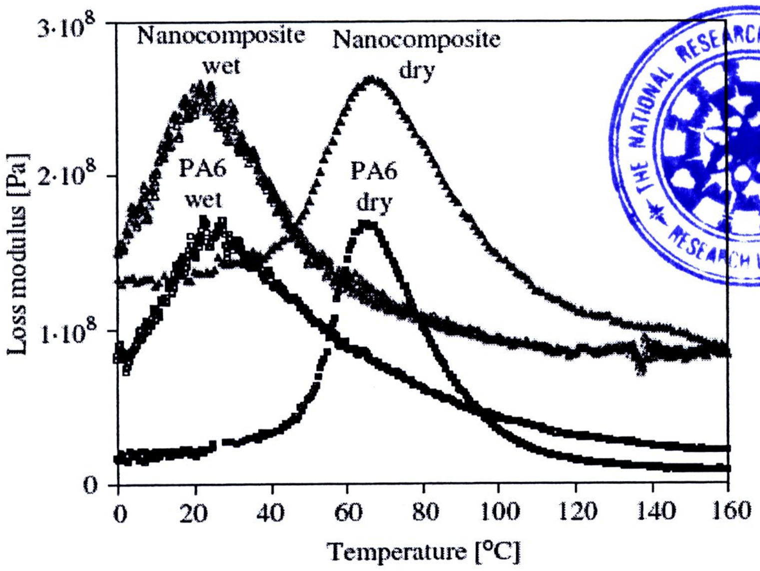

Figure 3.8 Loss modulus of PA6 and nanocomposite as a function of temperature in dry and moisture-conditioned samples [56]

The glass transition temperature, T_g, determined by DMA, corresponds to the peaks in the loss modulus curves. The T_g was the same in unfilled PA6 and the nanocomposite, but it decreased from around 65 °C in dry condition to around 20 °C as a result of moisture conditioning.