The Effects of inorganic Fluids on the Properties of Thermoplastics

Farhat Eljelane Abubaker

Mechanics Department of the Higher Institute of Sciences and technology, Aljofra-sokana, Libya

Abstract

The first polyethylene plant came on stream in 1939. This challenging, resilient material found immediate application as a bold for high-frequency low- voltage cables in radar, and its low-loss properties were later exploited in high-performance transatlantic submarine cables. The objective of this project is to look at the effects of inorganic fluids on the mechanical and physical properties of the thermoplastics, using the sulphuric (H_2SO_4) acid 98 % which was used to make three environments (1 M, 0.1 M, and 0.01 M), and other two environments, water and dry air. The polymers used in this project are Nylon 66 unfilled, Nylon 66 glass-fiber filled, and fiberglass. They were immersed in these environments to see the changes in their properties during the time of ten weeks, by tensile and Stress-Strain test.

Keywords: Nylon 66, glass, fiber, polymers, water

1. Introduction

The modern thermoplastics industry dates from 1920's when the first processing machinery specifically designed to make articles from thermoplastic on a mass-production scale anticipated the commercial production of materials synthesized from chemical feedstocks rather than from naturally occurring substances.

The first commercial injection molding machines designed for thermoplastics used injection rams actuated by compressed air. The early 1930's saw the use of pre-plasticization units (in which the plastic was melted before being fed to the injection cylinder) and by the end of the decade shot weights of over a kilogram had been achieved, using hydraulically operated rams. Machines of more modest capacity were by then already capable of fully automatic operation. In the mid-thirties the early extruders designed for thermoplastics came on the market.

PVC was in commercial production by the end of 1920's and in a plasticized form it was replacing rubber for insulating electric cables as early as 1932. Unplasticized PVC, available in 1937, was hard, stiff and tough, and its good chemical resistance was exploited in chemical plant.

The 1930's saw the commercial introduction of three other important thermoplastics: Polymethylmethacrylate(acrylic), Polystyrene and low-density polyethylene, the first two having natural outstanding transparency. Acrylic first became available in the form of clear, stiff, hard cast sheet which could be readily shaped and which was tougher and safer than glass: it rapidly could be readily replaced glass inter layered with cellulose nitrate in aircraft canopies. Acrylic molding powders also became available in the mid-thirties, albeit in limited quantities. Although polystyrene was cheap, stiff, crystal

clear and extremely easy to process, it made an unpromising start because of its extreme brittleness but in a modified form it was later to become an important material.

Further important materials to be introduced in the 1940's were nylon, ABS and PTFE (polytetrafluoroethylene). The high strength, stiffness and abrasion resistance of nylon were exploited in injection moulded gears and other components which replaced high quality metal ones in light machinery. The tough ABS materials were introduced in the late 1940's and a toughened, and therefore much improved, 'impact resistant' polystyrene at the beginning of the 1950's. These materials owed much to the earlier synthesis of general purpose rubbers deriving from butadiene and styrene; and the development of the synthetic rubbers stemmed from the need to find a material which was more elastic than plasticized PVC, which was originally used as a natural rubber replacement. PTFE entered commercial production at the end of the 1940's. It is a soft flexible material, chemically inert, an excellent electrical insulator has outstanding non-stick characteristics and can withstand continuous temperatures in the range -250 °C to +250 °C.

2. NYLON

Nylon (polyamides) forms family of thermoplastics. All members are structurally interrelated and show a general pattern of behavior, but each nylon is a distinct chemical entity. Nylons are characterized by high strength, good toughness, and good abrasion and chemical resistance, particularly to non-acidic substances, fuels and oils. Mechanical components made from them have excellent wear resistance and often be used without lubrication. Glass- fiber filled nylons possess several advantages over the unfilled grades: they are stronger and stiffer, have an increased working temperature range and greater dimensional stability. Thus the usefulness of the nylons is extended still further, notably applications where metal die castings have previously been used.

All the nylons in their equilibrium state contain a small amount of water: the more water it absorbs, the more flexible, soft and tough does nylon become. The absorbed water also causes nylons to swell slightly, although this is often unimportant because the accompanying increases in flexibility and resilience allow the component to deform slightly, thus tending to cancel the effect of small dimensional changes. A further point is that the absorption of water is a very slow process and therefore day-to-day variations in humidity have a negligible effect on the performance of any nylon part.

Nylons were developed as a result of work carried out in the 1930's by W. H. Carothers on 'condensation polymerization', i.e. the formation of large molecules containing reactive groups, with the elimination of a simple substance such as water, as opposed to 'addition polymerization' in which molecules are combined by breaking double bonds and joining the resulting activated molecules together.

Nylons are formed from reactions between molecules containing amino (-NH2) and carboxylic acid (-COOH) groups.

More recently, nylons have been produced from one type of molecule (amino acid) only, one containing both the reactive groups necessary.

Despite the undoubted general excellence nylon and other polymers, there remains the need to modify and regulate the properties of any nylon or other polymer to overcome specific deficiencies and make it more suitable for a particular application. The use of polymers at the levels of engineering can be extended by using additives in which range from 0.1% to over 40%.

In general terms, modifications can be considered in three categories:-
a) The addition of fibers (glass).

b) The addition of inorganic particulate fillers.

c) The addition of rubbery components.

The benefit of (a), the addition of glass fiber to nylon is that it improves heat resistance, rigidity and creep resistance.

The benefit of (b), the additions of inorganic particulate fillers give the advantage of dimensional stability.

The benefit of (c), the additions of rubbery components give the advantage of improved impact strength and low temperature performance. The main reason why so such work has gone into the development of modified nylon or other thermoplastics rather than the creation of new polymers is largely cost.

Table 1: Properties Of Nylon 66 and Nylon 66 Glass-filled

property	Units	Typical Value	
		Nylon 66	Nylon 66 Glass-filled
Density	g/cm²	1.14	1.39
Crystalline m point	°C	264	264
Coefficient of linear	1/°C	$9.3 * 10^{-5}$	$3\text{-}7 * 10^{-5a}$
Thermal expansion -20 to 80 °C	1/°F	$5.2 * 10^{-5}$	$1.7\text{-}3.9 * 10^{-5}$

3. Experimental

• Stress Corrosion Cracking:

The environments in which most engineering materials rails are used are seldom inert. In many cases environmental attack can limit the useful lifetime of components. Corrosion is the most common result of environmental attack. But there are more subtle interactions that may limit service life even if general corrosion problems have been eliminated. One such particularly insidious interaction is stress corrosion cracking (SCC).

Stress corrosion cracking, as the name suggests, is the advanced of a crack in a material subjected to stress in the presence of a hostile gaseous or liquid environment. SCC may be particularly difficult to detect for the following reasons:

1. Environments that are only mildly corrosive to the material may cause severe SCC.

2. The required concentration of the harmful component in the environment may be extremely small and its presence difficult to detect.

3. The attack may be highly localized as one or a number of small cracks that propagate undetected to failure.

4. Residual stresses in components are often great enough to cause stress corrosion cracking even in the absence of applied stresses.

As with fatigue cracking, there are two approaches to the measurement of lifetimes in components experiencing SCC. One approach involves determining the time required to cause failure of smooth, uncracked specimens subjected to stresses in the environment in question. If the stress is low enough, time to failure becomes excessively long and an apparent threshold stress below which SCC does not occur can be defined. In such a test, the time to failure necessarily involves the time required to initiate the crack by localized chemical attack and the time required to propagate the crack to failure. As in

fatigue, when small cracks are already present, the time to failure may be much shorter than that predicated from tests on smooth specimens.

- **The Tensile Test:**

This is one of the most widely used mechanical tests. It provides certain data as the tensile strength, strain, and Young's modulus. In addition it indicates the extent of elastic and plastic deformation and so provides a measure of toughness.

The tensile properties obtained to some extent on the size and shape of the test specimen. Standardized specimens were therefore used.

Tensile tests used with plastic test pieces were used to obtain stress-strain data. The term 'tensile strength' is the stress corresponding to the maximum force. However, the tensile modulus, i.e. the slope of the stress-strain graph over the proportion region, was not obtained, because there is no really straight-line part of the stress-strain graph. The stress-strain properties of plastics are much more dependent than metals on the rate at which the strain is obtained. Another factor that is important is the effect of temperature on the properties of plastics.

The following formulas are used to calculate the properties:-

Stress= Force / Area (MPa)

$\sigma = F/A$ (1)

Strain= Extension / Original Length

$\varepsilon = \Delta L/L$ (2)

Young's Modulus = Stress / Strain (GPa)

$E = \sigma/\varepsilon$ (3)

RESULTS

All the results for tensile test were taken from the graphs (tensometer traces). The Elastic Extension Magnification is 4cm = 0.1 cm

i.e. Imm= 2.5×10^{-3} mm

Force Magnification is 1 kN = 16 mm

i.e. Force = Force Reading from the Elastometer Traces/16

Stress Force / Cross-Sectional Area (MPa)

$\sigma = F/A$ (4)

Strain = Elastic Elongation / Original Length X 100 (%)

$\varepsilon = \delta 1/1$ (5)

Young's modulus = Stress / Strain (GPa)

$E = \sigma/\varepsilon$ (6)

The Cross-Section Area of the Specimen (A) = 40 mm²

$A = 4 \times 10^{-5}$ m²

Original Length (I) = 100 mm

$1 = 100$ mm $= 100 \times 10^3$ m $= 10^{-1}$ m

Table 2: Stress strain results for Nylon 66 glass-filled immersed in 1 M H_2SO_4

Strain (%)	2W Stress (MPa)	4W Stress(MPa)	6W Stress(MPa)	8W Stress(MPa)	10W Stress(MPa)
0	0	0	0	0	0
1.25	21.875	17.19	17.19	12.50	10.90
2.50	43.75	35.94	32.80	25	23.40
3.75	64.10	54.68	50	34.40	32.80
5	81.25	73.44	67.20	42.20	37.50
6.25	95.30	89.10	76.60	45.30	
7.25	100.10	100	82.90	45.40	
7.50		101.60	84.40	45.40	
8.25		106.25	84.50	45.50	
8.75		107.80		45.50	
9.50		109.40			

Table 3: Stress strain results for Nylon 66 glass-filled immersed in Water

Strain (%)	2W Stress (MPa)	4W Stress(MPa)	6W Stress(MPa)	8W Stress(MPa)	10W Stress(MPa)
0	0	0	0	0	0
1.25	21.875	17.26	14.14	12.57	15.625
2.50	42.26	37.60	31.25	28.20	29.69
3.75	62.50	53.10	48.44	43.75	45.31
5	78.2	71.9	65.625	56.25	53.2
6.25	90.7	85.9	81.25	62.5	57.8
7.5	98.4	95.3	92.18	64.1	
7.75		96.875	93.75	64.14	
8.75		100	98.44		
10			100		

Table 4: Stress strain results for Nylon 66 glass-filled immersed in 0.01 M H_2SO_4

Strain (%)	2W Stress (MPa)	4W Stress(MPa)	6W Stress(MPa)	8W Stress(MPa)	10W Stress(MPa)
0	0	0	0	0	0
1.25	18.75	17.1875	17.1875	14.14	15.625
2.50	40.625	35.94	31.25	29.6875	35.9375
3.75	60.938	53.2	51.5625	43.75	50
5	79.76	75	67.1875	53.125	56.25
6.25	95.39	89.06	79.765	56.25	59.375
7.5	103.2	98.44	87.5		
7.75	104.69	100	87.578		
8.75		101.64	89.06		
10		103.125	89.0625		

Table 5: Stress Strain results for Nylon 66 glass-filled immersed in 0.1 M H_2SO_4

Strain (%)	2W Stress (MPa)	4W Stress(MPa)	6W Stress(MPa)	8W Stress(MPa)	10W Stress(MPa)
0	0	0	0	0	0
1.25	17.1875	15.7	14.1875	12.5	15.625
2.50	31.25	31.25	29.76	25	31.33
3.75	51.5625	46.875	43.83	37.578	45.39
5	65.625	59.375	54.76	45.3125	54.76
6.25	81.25	65.625	59.45	48.4375	
7.5	82.89	65.75	60.94	48.52	
7.75	82.91	67.19			
8.75	89.92				

Table 6: Tensile test results, Dry air, nylon 66, glass filled

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	81.25	5.75	1.4
2	91.5	7.55	1.2
3	93	8	1.16
4	93.75	7.5	1.25
5	132.8	9.625	1.38
Average	98.46	7.685	1.278

Table 7: Tensile test results, Dry air, nylon 66, glass unfilled

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	49.2	30	0.164
2	50	22.5	0.22
3	48.5	22.5	0.22
4	45.3	22.5	0.2
5	45.3	22.5	0.2
Average	47.66	24	0.2008

Table 8: Tensile test results, nylon 66, glass filled (immersed in water for 2 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	98.4	7.5	1.312
2	80.5	7.5	1.0733
3	75.8	7.5	1.0104
4	101.6	7.5	1.3547
5	115.6	8.75	1.3211
Average	94.38	7.75	1.2143

Table 9: Tensile test results, nylon 66, glass filled (immersed in 1 M H_2SO_4 for 2 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	108.3	7.5	2.5101
2	115.6	5	2.3125
3	100	7.25	1.3793
4	98.4	7	1.40625
5	57.8	6.25	0.925
Average	96.02	6.6	1.70663

Table 10: Tensile test results, nylon 66, glass filled (immersed in 0.01 M H_2SO_4 for 2 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	116.41	9	1.2934
2	111	8	1.3875
3	104.7	7.75	1.3508
4	113.3	8.625	1.3134
5	73.4	7.5	0.9792
Average	103.762	8.175	1.26486

Table 11: Tensile test results, nylon 66, glass filled (immersed in 0.1 M H_2SO_4 for 2 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	43	7.25	0.5931
2	109.4	7.55	1.4487
3	83.6	9.125	0.9161
4	112.5	8.25	1.3636
5	120.3	9.25	1.3005
Average	93.76	8.285	1.1244

Table 12: Tensile test results, nylon 66, glass filled (immersed in Water 4 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	100.8	9.75	1.0337
2	98.4	9	1.0933
3	97.7	9	1.0851
4	103.1	9.625	1.0712
5	100	9.5	1.0526
Average	100	9.375	1.06718

Table 13: Tensile test results, nylon 66, glass filled (immersed in 1 M H_2SO_4 4 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	104.7	9.25	1.1318
2	109.4	10.25	1.0671
3	74.2	9.5	0.78125
4	110.2	10.25	1.07561

5	75	9.5	0.7895
Average	94.7	9.75	0.96905

Table 14: Tensile test results, nylon 66, glass filled (immersed in 0.1 M H_2SO_4 4 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	67.188	7.75	0.867
2	101.56	9	1.1284
3	67.187	8	0.840
4	107.81	10.25	1.052
5	60.94	7.25	0.8405
Average	80.937	8.45	0.94558

Table 15: Tensile test results, nylon 66, glass filled (immersed in 0.01 M H_2SO_4 4 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	70.3	8.75	0.8034
2	110.25	11.25	0.980
3	103.125	9.75	1.0577
4	106.25	10.25	1.0366
5	100	9	1.1111
Average	97.985	9.8	0.99776

Table 16: Tensile test results, nylon 66, glass filled (immersed in Water 6 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	100	10	1
2	101.56	10.25	0.9909
3	95.31	11.5	0.829
4	100	10.25	0.975
5	59.4	7	0.8482
Average	91.254	9.8	0.92874

Table 17: Tensile test results, nylon 66, glass filled (immersed in 1 M H_2SO_4 6 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	53.125	8	0.6641
2	90.625	8.875	1.021
3	85	8.75	0.9714
4	48.44	7.627	0.6352
5	48.44	7.75	0.625
Average	65.126	8.2	0.78336

Table 18: Tensile test results, nylon 66, glass filled (immersed in 0.1 M H_2SO_4 6 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	98.44	10.125	0.9722
2	92.2	10.125	0.9160
3	57.8	7.625	0.758
4	60.94	7.75	0.7863
5	60.94	8	0.7617
Average	74.064	8.725	0.83776

Table 19: Tensile test results, nylon 66, glass filled (immersed in 0.01 M H_2SO_4 6 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	90	9	1
2	90	9.25	0.973
3	60	7.25	0.8276
4	62.5	7.5	0.8333
5	96.9	9.25	1.0476
Average	79.88	8.45	0.9363

Table 20: Tensile test results, nylon 66, glass filled (immersed in Water 8 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	59.375	7.5	0.7917
2	48.44	7.75	0.625
3	57.8	7.5	0.7707
4	84.4	9.75	0.8656
5	82.8	8.75	0.9463
Average	66.563	8.25	0.79986

Table 21: Tensile test results, nylon 66, glass filled (immersed in 1 M H_2SO_4 8 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	41.4	7.5	0.552
2	46.1	8.75	0.5266
3	39.1	7.5	0.5213
4	60.94	5.75	1.0598
5	40.625	8	0.5078
Average	45.633	7.5	0.6335

Table 22: Tensile test results, nylon 66, glass filled (immersed in 0.1 M H_2SO_4 8 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	49.22	7.5	0.6563
2	43.75	6.75	0.6481
3	42.97	7.25	0.5927
4	45.3	7.25	0.6248

5	73.44	7.5	0.9792
Average	50.936	7.25	0.7

Table 23: Tensile test results, nylon 66, glass filled (immersed in 0.01 M H_2SO_4 8 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	56.25	7.5	0.75
2	52.5	6.75	0.7778
3	82.8	9	0.92
4	95.3	9	1.059
5	39.1	5.375	0.7274
Average	65.14	7.525	0.84684

Table 24: Tensile test results, nylon 66, glass filled (immersed in Water 10 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	49.2	5.25	0.9371
2	48.44	5.125	0.9452
3	57.8	5.375	1.0753
4	82.8	10	0.828
5	52.5	7	0.75
Average	58.148	6.55	0.90712

Table 25: Tensile test results, nylon 66, glass filled (immersed in 1 M H_2SO_4 10 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	39.1	3.75	1.0427
2	50	5.25	0.9524
3	39.1	4.5	0.869
4	31.25	2.75	1.1364
5	37.5	4.5	0.8333
Average	39.39	4.15	0.96676

Table 26: Tensile test results, nylon 66, glass filled (immersed in 0.1 M H_2SO_4 10 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	31.25	3.75	0.8333
2	56.25	5.5	1.0227
3	65.625	6.25	1.050
4	Broken	Broken	Broken
5	60.75	6.5	0.9346
Average	42.775	4.4	0.76812

Table 27: Tensile test results, nylon 66, glass filled (immersed in 0.01 M H_2SO_4 10 weeks)

Specimen No	Strength (MPa)	Strain (%)	YM (GPa)
1	59.4	6.375	0.9318
2	29.7	4.25	0.699
3	73.4	10	0.734
4	71.9	8.25	0.8715
5	57.8	6.25	0.9248
Average	58.44	7.025	0.83222

Table 28: Tensile test results,(Water environment) nylon 66 unfilled

Mech property	No of week				
	2	4	6	8	10
Strength (MPa)	27.2	28.1	25	22.2	14.1
Strain (%)	2.15	2.45	2.5	2.14	2.15
YM (GPa)	1.2	1.15	1	1.04	0.65

Table 29: Tensile test results, (Sulphuric Acid 1M concentration) nylon 66 unfilled

Mech property	No of week				
	2	4	6	8	10
Strength (MPa)	34.3	34.7	24.7	17.2	16.6
Strain (%)	2.3	1.88	2.6	2.45	1.9
YM (GPa)	1.5	1.85	0.92	0.7	0.87

Table 30: Tensile test results, (Sulphuric Acid 0.1M concentration) nylon 66 unfilled

Mech property	No of week				
	2	4	6	8	10
Strength (MPa)	34.7	31.9	25	18.4	15.3
Strain (%)	2.4	2.5	2.3	2.37	1.9
YM (GPa)	1.45	1.28	1.09	0.78	0.81

Table 31: Tensile test results, (Sulphuric Acid 0.01M concentration) nylon 66 unfilled

Mech property	No of week				
	2	4	6	8	10
Strength (MPa)	33.1	29.1	24.1	21.9	14.1
Strain (%)	1.59	2.65	2.4	2.45	1.21
YM (GPa)	2.09	1.1	1	0.89	1.16

Table 32: Tensile test results,(Water environment) nylon 66 unfilled

Mech property	No of week				
	2	4	6	8	10
Strength (MPa)	94.38	100	91	66	58
Strain (%)	7.75	9.375	9.8	8.25	6.55

YM (GPa)	1.2	1.1	0.93	0.7994	0.91

Table 33: Tensile test results, (Sulphuric Acid 1M concentration) nylon 66 unfilled

Mech property	No of week				
	2	4	6	8	10
Strength (MPa)	95.6	94.4	65	45	39.2
Strain (%)	6.6	9.75	8.2	7.5	4.15
YM (GPa)	1.71	0.968	0.783	0.633	0.97

Table 34: Tensile test results, (Sulphuric Acid 0.1M concentration) nylon 66 unfilled

Mech property	No of week				
	2	4	6	8	10
Strength (MPa)	93.4	80.4	71.4	50.4	42.775
Strain (%)	8.25	8.45	8.725	7.25	4.4
YM (GPa)	1.12	0.945	0.84	0.7	0.7681

Table 35: Tensile test results, (Sulphuric Acid 0.01M concentration) nylon 66 unfilled

Mech property	No of week				
	2	4	6	8	10
Strength (MPa)	103.4	98	79.6	65	58
Strain (%)	8.175	9	8.45	7.525	7.025
YM (GPa)	1.26	0.997	0.94	0.85	0.892

4. Conclusion and Recommendation

Since Plastic generally contain various additives as well as their base polymer, the chemical resistance of each plastics material varies according to the nature and amount of these additives. It is difficult, therefore, to describe and even more so to compare the chemical resistance of plastics, and their behavior in different chemical environments must be assessed individually, the necessary detailed information usually being available from the raw materials manufacturers.

However, some broad generalizations can be made about the chemical resistance of plastics in order to indicate their usefulness in the presence of liquids. The interaction of plastics with liquids may be of a physical rather than a chemical nature. Thus, fuels, fats, oils, and organic solvents may cause swelling, softening, and ultimately dissolution. The resistance of plastics to such liquids varies from complete to very poor, depending on the nature of the plastics, the solvent, and the temperature. Water also penetrates some plastics causing them to soften and swell. The most important example of this is provided by nylon, which is plasticized by the water it absorbs. Plastics are generally resistant to weak acids and weak alkalis. However, strong oxidizing acids may attack plastics chemically, causing discoloration and embrittlement.

Nylon 66 unfilled behaves in a plastic manner since there is uniform rate of extension with a constant force. Therefore can only calculate the maximum stress at the optimum elongation where the stress and elongation both remain constant.

It is not possible to calculate Young's Modulus because the rate of extension is mot the same as the rate of the force increasing, therefore not linear.

Nylon 66 glass filled shows a brittle manner of failure therefore can calculate stress, strain and Young's Modulus.

Young's modulus of elasticity

Nylon 66 unfilled will have no true Young's modulus as plastic filled since brittle (elastic) will show Young's modulus

Nylon 66 glass filled have high value of Young's modulus compared with Nylon 66 unfilled Young's modulus, about 6 times more elastic than unfilled or unfilled is 6 times more plastic than Nylon 66 filled. The Planes shows that the results obtained are as expected in most of the cases, however there are some exceptions. It's not always necessary that all the fibers are affected under the same circumstances. This, however, doesn't mean that precautions do not have to be taken because its unpredictable that which fibers are going to be affected. Since this is a matter of vast impotence therefore, it's absolutely necessary to test the fibers under different conditions (e.g. below freezing point, in very hot temperature, etc.) to avoid any form of disaster.

It has been shown that dilute mineral acids (and water in some cases) can cause cracking of glass fibre. Therefore, when employing glass fiber composites in load-bearing situations, it is necessary to ensure that the fibers themselves are protected from direct exposure to the acid.

REFERENCES

1. Avner, S. H. "Introduction to physical metallurgy. New York": McGraw-hill.1974, Vol 2, pp. 481-497

2. BOLTON, William. Engineering materials technology. Elsevier, 2013.

3. HARPER, J. F. Materials for the Engineering Technician–Second edition. RA Higgins. Edward Arnold, London. 1988. 407 pp.

4. Materials Technology for technicians, 2nd Edition, W Bolton, 1981. Butterworth & Co (Publishers) Ltd., 1981.

5. Testing of Polymers, Volume 2 John V Schmitz, 1966 A division of John Wiley, New York.

6. The Testing of engineering Materials, 4th Edition, Harmer E Davis, George Earl Troxell, George F W Hauck, McGraw-Hill Book Company, 1982.

7. Engineering Materials and their Applications, 4th Edition, Flinn/ Trojan, Houghton Mifflin, 1990.

8. Engineering Properties of Thermoplastics, RM Ogorkiewicz, Wiley-Interscience, 1970.

9. Engineering Composite Materials. Bryal Harris The Institute of Metals, 1986.

10. Stress Corrosion Cracking and its implications for the long-term durability of E-glass fibre composites. F.R. Jones, J.W. Rock and A.R. Wheatley Composites. Vol 14. No 3. July 1983.

11. Hogg, P.J, Hull, D. and Legg ENDIY M.J., Failure of GRP in corrosive environments in composite structures edited by I.H. Marshall, (Applied Science, London, 1981), p 106.

12. Jack C.M.,"Electromagnetic Effects on the Different Kinds of Water", Journal of Electromagnetic Effects, 1992,2 (4), 47–76.