International Journal of Engineering& Scientific Research
Vol. 6 Issue 7, July 2018,
ISSN: 2347-6532 Impact Factor: 6.660
Journal Homepage: http://www.ijmra.us, Email: editorijmie@gmail.com
Double-Blind Peer Reviewed Refereed Open Access International Journal - Included in the International Serial Directories Indexed & Listed at: Ulrich's Periodicals Directory ©, U.S.A., Open J-Gage as well as in Cabell's Directories of Publishing Opportunities, U.S.A

INFLUENCE OF $CaCO_3$ CONTENT ON THE STRESS-STRAIN AND IMPACT STRENGTH RESPONSE OF UNSATURATED POLYESTER TILE

Nwapa, Chinedu and Madufor, I. C.
Department of Polymer and Textile Engineering,
School of Engineering and Engineering Technology,
Federal University of Technology, Owerri
Corresponding Author Email Id: **edunwapa@yahoo.com**

Article Received: 4th June, 2018 Article Revised: 12th June, 2018 Article Accepted: 25th June, 2018

Abstract
The investigation into the mechanical properties of $CaCO_3$ filled unsaturated polyester tiles were studied. The specimen were labeled as follows; specimen B (16 % $CaCO_3$); specimen C (31 % $CaCO_3$); specimen D (44 % $CaCO_3$); specimen E (55 % $CaCO_3$). The control specimen is A (0 % $CaCO_3$). The impact strength of the specimen increased with $CaCO_3$ content and specimen E had the best impact strength of 74.60 % from the control specimen. The Young modulus also increased with $CaCO_3$ content but dropped after 44 % $CaCO_3$ loading. Hence, specimen D (44 % $CaCO_3$) had the best Young modulus of 25 % from the control specimen.

1.0 Introduction
Polymeric composites are physical mixtures of a polymer (the matrix) and a reinforcing filler(the dispersed phase) that serves to improve some mechanical property such as modulus or abrasion resistance. Fillers may be inorganic (e.g., calcium carbonate) or organic (graphite fibre or an aromatic polyamide such as Kevlar). Virtually any material can be used as the composite matrix, including ceramic, carbon, and polymeric materials. Typically, matrices for polymeric composites are thermosets such as epoxy or (unsaturated) polyester resin: however, some engineering thermoplastics with Tg and good impact strength, such as thermoplastic polysulfones, have been used for composites. Principal applications for composites are in construction and transportation (Fried, 2003).
Harper (2000) reported in his book Modern Plastic Handbook that a thermosetting matrix is defined as a composite matrix capable of curing at some temperature from ambient to several hundred degrees of elevated temperature and cannot be reshaped by subsequent reheating. In general, thermosetting polymers contain two or more ingredients – a resinous matrix with a curing agent which causes the matrix to polymerize (cure) at room temperature or a resinous matrix and curing agent that, when subjected to elevated temperatures, will commence to polymerise and cure. Polyester matrices have had the longest period of use, with wide application in many large structural applications. They will cure at room temperature with a catalyst (peroxide) which produces an exothermic reaction. The resultant polymer is non-polar and very water resistant.
Nielsen et al (1994) stated in their book Mechanical Properties of Polymers and Composite that composite materials may be defined as materials made up of two or more components and consisting of two or more phases such materials must be heterogeneous at least on a microscopic scale. Composite materials may be divided into three general classes: (1) particulate-filled materials consisting of a continuous matrix phase and a discontinuous filler phase made up of discrete particles. (2) fibre-filled composites, and (3) skeletal or interpenetrating network composites consisting of two continuous phases.

2.0 Materials and methods

2.1 Materials

i. unsaturated polyester resin
ii. MEKP-Methyl Ethyl Ketone Peroxide (catalyst)
iii. cobalt octate (accelerator)
iv. silicone wax (internal mould release)
v. calcium carbonate – $CaCO_3$

2.2 Equipment

i. Injection moulding machines produced by Hyun Sung Hydraulic machine Korea, model number HIS673H.
ii. Adenturer electronic weighing balance manufactured by Ohaus Corporation China, Serial number 8726479733, item number AR3130.
iii. Tensometer produced by Italy with model number TM-2.
iv. Calipers
v. Scissors
vi. Stirrer
vii. Thermometer
viii. Electric stove
ix. Micrometer screw gauge
x. Dumbbell shaped metallic mould
xi. Manual press

2.3 Method

2.3.1 Mould preparation

A rectangular polyethylene block was first extruded, then, the mould was casted with unsaturated polyester as the matrix and the fiberglass as the fibre. I now used hand to make the mould to shape or form of the extruded rectangular polyethylene block, allowed it to cure and finally removed the extruded rectangular block from the mould.

2.3.2 Mixing

A sample for control experiment was first prepared for both the impact and modulus response test. This was done by pouring specific quantity of the UP resin in a bowl then adding a little quantity of accelerator and catalyst with due regard to the formulation. These were manually mixed properly and now brushed into the mould gradually and poured subsequently. The content in the mould was allowed to cure at room temperature until it sets. The other samples were now prepared but now specific quantity of $CaCO_3$, for example 20g, 40g, 60g, etc, was added and the routine mixing and curing followed. In each case mould release was applied to the mould for easy removal of moulded samples.

2.3.3 Subsequent processing

The sample for impact behavior was simply a rectangular block and has dimensions as 100 mm X 75 mm X 10 mm. On the other hand, the sample for modulus test was moulded first as a rectangular block and then cut to a dumb-bell shape manual press. The rectangular block has dimension of 120 mm X 25 mm X 3 mm. At the end both samples have shapes shown below in figures 8 and 9.

3.0 Procedure for data collection and analysis

3.1 Impact Strength test

The Izod impact test was conducted starting with the control experiment, that is, the zero filler sample. The procedure involve:

1. Positioning the pointer, ideal and pendulum arm at rest position.
2. The sample is now clamped vertically in a vice.
3. Then the pendulum arm with the attached weight is allowed to strike the sample.

It is important to note that all the samples were weighed before the destructive test were carried out on them. The pendulum arm descended at a velocity of 11ft/s and the specimen was placed 2.1cm above the root of the vice.

3.2 Impact Strength measurement

The response of the sample to the load (steel ball and pendulum arm) is got from scale and the average is taken as the real value for deflection of each of the sample. Originally, the weight of each sample was noted. Then a plot of load over deflection gives the impact strength behavior for the unsaturated polyester tiles.

3.3 Stress-Strain measurement

Stress-strain test on the other hand was conducted using a tensometer. The steps involved after noting the weight are:

1. Clamping the sample firmly on the tensometer.
2. Slotting the graph paper into the rotating drum.
3. Then the axle is gradually rotated until the specimen finally breaks.

It should be noticed that the graph on the rotating drum is showing an indication of the response of the sample to the destructive test.

3.4 Stress-Strain measurement

The response of the specimen as indicated on the graph is recovered from the rotating drum and a new graph is plotted. Now using the values in the first graph as a guide the measurement of the stress-strain response are got from calculations. This is shown in the next chapter. The stress-strain result gives an idea of the moduli behavior of the unsaturated polyester tiles.

4.0 Results and Discussions

4.1 Impact test results

The results of the impact strength are shown in the table below. The parameters used are defined as well.

h_0 = Distance of ball center to the vice = 546mm
P = Mass of pendulum arm = 2.10Kg
g = Acceleration due to gravity = 9.81m/s^2
h_1 = Deflection
$mg(h_0 – h_1)$ = Impact energy
Load(Kg) = Mass of the different samples

4.1.1 Calculation

From the slope of the graph that is equivalent of the impact strength we have that

$$\text{Slope of sample A} = \frac{\text{change in y-axis}}{\text{change in x-axis}} = \frac{0.06 - 0}{0.38 - 0} = \frac{0.06}{0.38}$$

$$= 0.16\text{Kg/m}$$

Similarly calculations are made for the other samples and their impact strengths are shown in the table below.

4.1.2 Discussion

It could be seen from the result above that the impact strength response of $CaCO_3$ filled unsaturated polyester tile increases with load and decreases with the deflection. Besides, deviations in this response increase down the column.

4.2 Modulus test result and calculations

The values for other parameters are calculated as follows:

Area = 6 X 50 X 3 = $900mm^2$

L_0 = original length of sample (gauge length) = 50mm

Load and extension are got from plot on the graph sheet from the rotating drum.

$$\text{Stress} = \frac{\text{load}}{\text{Area}}$$

$$\text{Strain} = \frac{\text{change in length}}{\text{original length}} = \frac{\text{extension}}{\text{original length}}$$

4.2.1 Discussion

From the results above, it is clear that the specimen respond to modulus in such a manner that specimen D has the best response. Therefore, for a better Young's Modulus behavior very low or high $CaCO_3$ content is not proper. Finally, the highest deviation from ideality was got with sample E.

5.0 Conclusion

From this study, it was noticed that specimen E (55 % $CaCO_3$) had the best impact strength of 74.60% increase while specimen D (44 % $CaCO_3$) had the best Young modulus of 25 % rise. Therefore, the best specimen is D (44 % $CaCO_3$) with impact strength rise of 69.23 %.

References

Allen, K. W. (1988) Adhesion 12, Elsevier Applied Science Publishers Ltd. England. 33 – 35.

Billmeyer, F. W. (1984) Textbook of Polymer Science, 3rd ed., John Wiley and Sons, N. Y., 442 – 445, 463.

Brostow, W. (1886) Polymer Engineering and Science, Vol. 36/No. 24, Society of Plastic Engineers, International Forum on Polymers, Dec. 1886, 2973 – 2977.

Cheremisinoff, Nicholas P. (1989) Handbook of Polymer Science and Technology, Vol. 1, Marcel Dekker inc., New York and Basel, 193 – 195, 448 - 449.

Clark, D. T and Feast, W. J. (1978) Polymer Surfaces, John Wiley and Sons, N. Y. 241 – 247.

Cowie, J. M. G. (1991) Polymers: Chemistry and Physics of Modern Materials, 2nd ed., Chapman and Hall N. Y. 394 – 397, 54 -57.

Crawford, R. J. (1990) Plastic Engineering, 2nd ed., Pergamon Press, N. Y., 1, 7, 43 – 44.

Dyson, R. W. (1990) Specialty Polymers, Blackie Academic and Professional. An Imprint of Chapman and Hall, London. 40 – 42.

Fried J. R. (2003). Polymer Science and Technology, Second Edition. Pearson Education, Inc. New Jersey, United State of America. 283 – 317.

Harper C. A. (2000) Modern Plastics Handbook. McGraw Hill Compaies, Inc. United State of America. 2.59 – 2.66, 6.3 – 6.7

Katchy, E. M. (2000) Introduction to Polymer technology, 1st ed., EI' Demak Publishers, Enugu, Nigeria, 180.

Katchy, E. M. (2000) Principles of Polymer Science. 1st ed. El' Demak Publishers. Enugu, Nigeria. 476 – 479.

Kroschwitz, I. J. (1992) Polymers Characterization and analysis, Encyclopedia Reprint Series, John Wiley and Sons, N. Y. 338 – 344.

Lambourne, R. (1988) Paint and Surface Coatings, Theory and Practice, John Wiley and Sons, N. Y., 61 – 65.

Nielsen L. E. and Landel R. F. (1994). Mechanical properties of polymers and composites, second edition, revised and expanded. CRC Press, Taylor and Francis Group. United State of America. 377 – 447.

Pearson, R. A. and Sue, H. J. (1996) Polymer Engineering and Science, Vol. 36/No. 18, Society of Plastic Engineers, Sept. 1996, 2327 – 2344, 2973 – 2977.

Seymour, B. R. (1990) Engineering Polymer Source book, McGraw-Hill Publishing Company, New York. 59 – 62, 274.

Appendix I

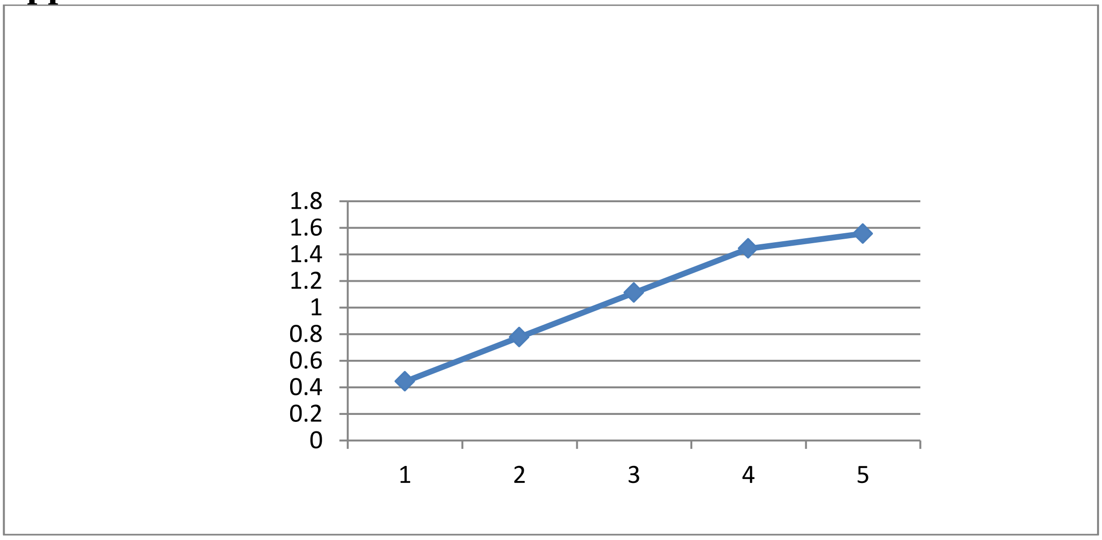

Figure 1: Stress-Strain curve for 0g composition of $CaCO_3$ in UP tile

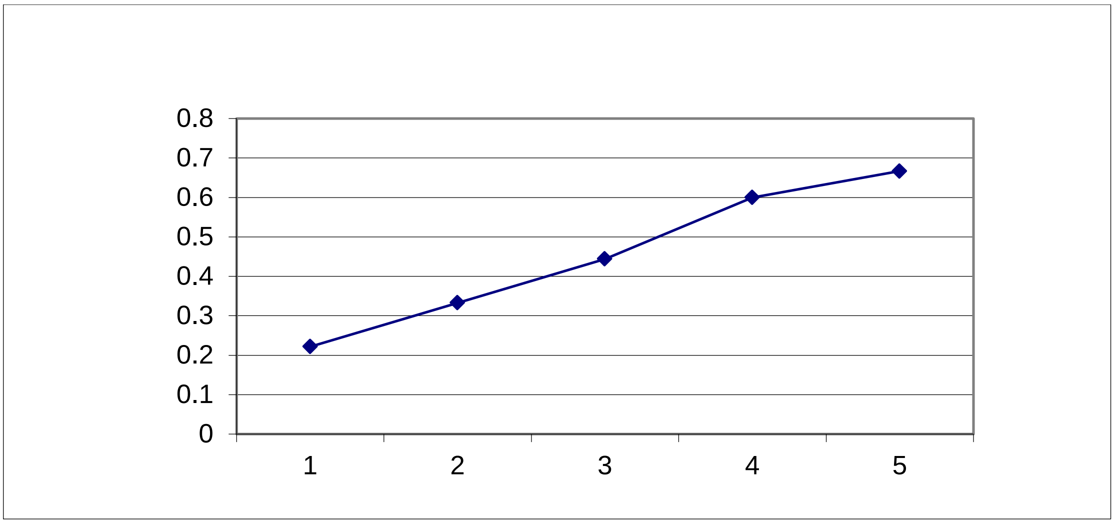

Figure 2: Stress-Strain curve for 20g composition of $CaCO_3$ in UP tile

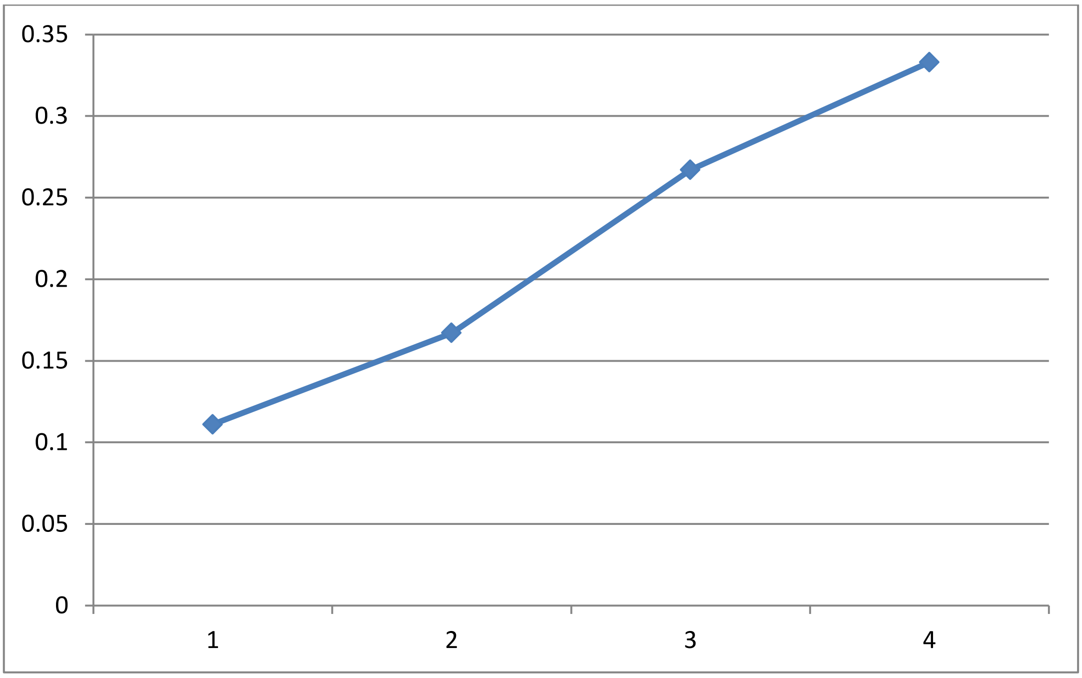

Figure 3: Stress-Strain curve for 40g composition of $CaCO_3$ in UP tile

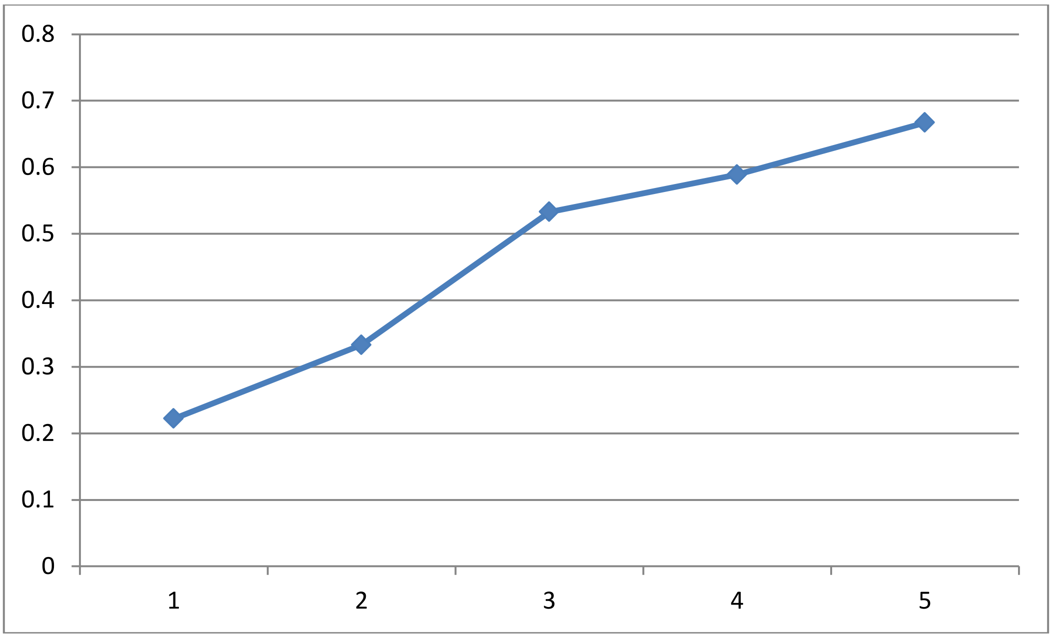

Figure 4: Stress-Strain curve for 60g composition of $CaCO_3$ in UP tile

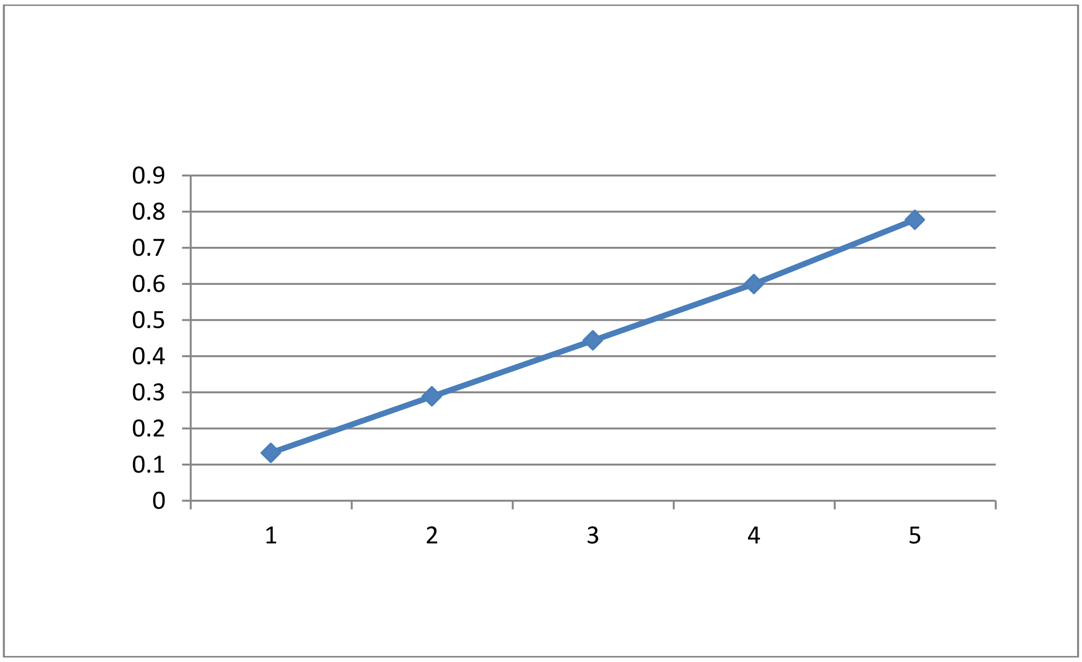

Figure 5: Stress-Strain curve for 80g composition of $CaCO_3$ in UP tile

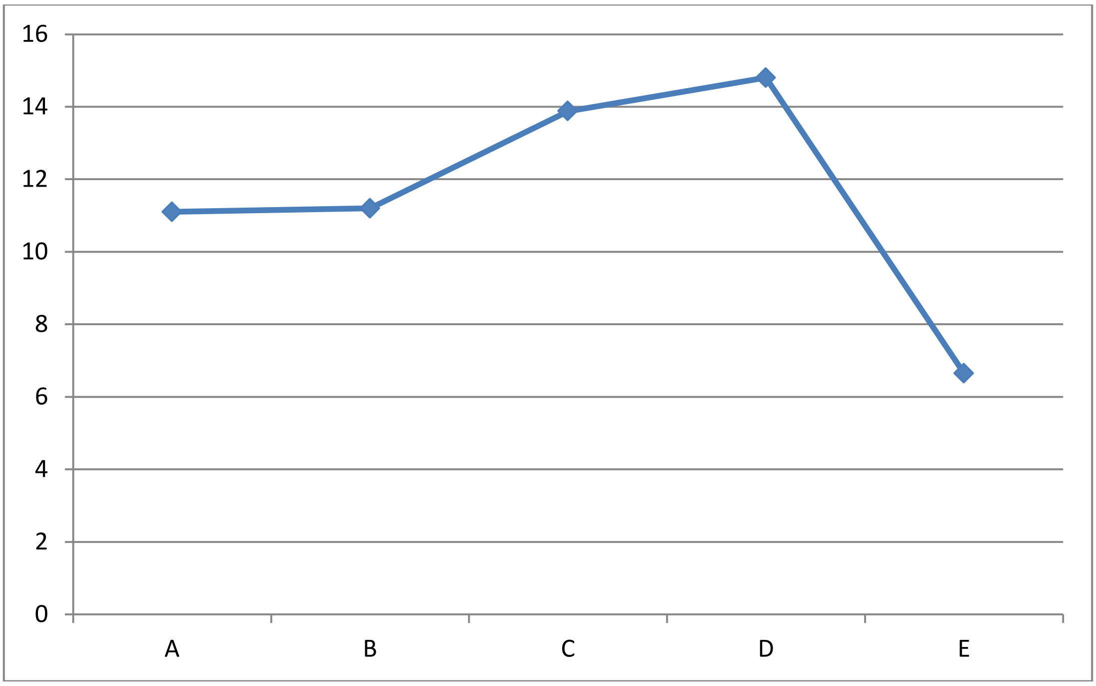

Figure 6: Effect of Young modulus on composition

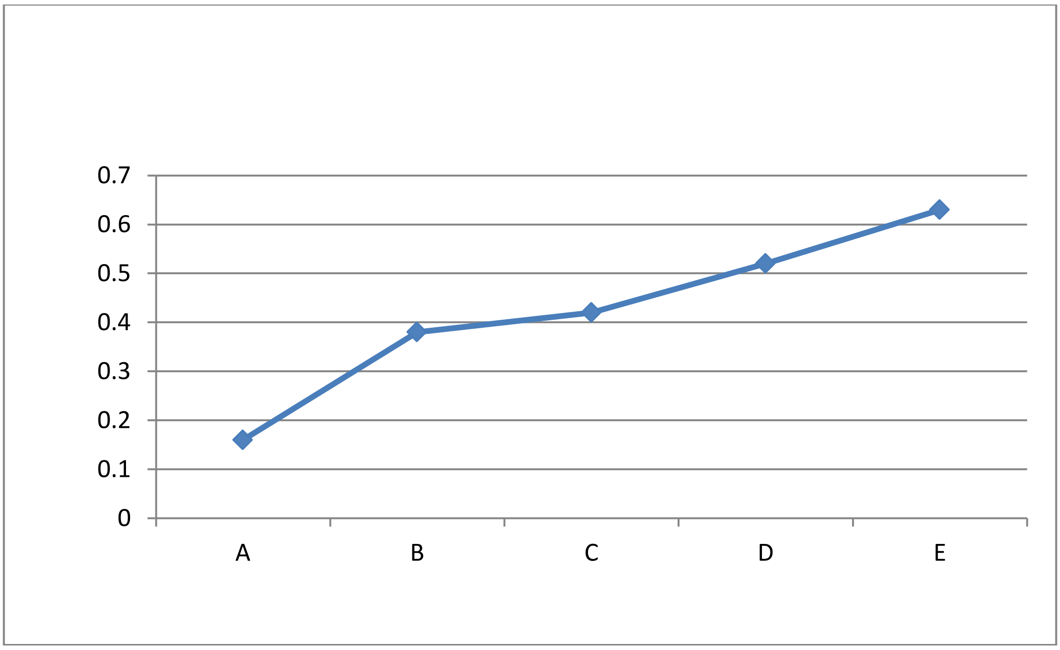

Figure 7: Effect of Impact Strength on composition

Appendix II

Table 5.1: formulation

Ingredients	Wt of Sample A (g)	Wt of Sample B (g)	Wt of Sample C (g)	Wt of Sample D (g)	Wt of Sample E (g)
UP resin	61.84	101.04	88.64	75.89	64.64
Filler	0	20.00	40.00	60.00	80.00
Catalyst	0.13	0.13	0.13	0.13	0.13
Accelerator	0.13	0.13	0.13	0.13	0.13
	62.10	121.30	128.90	136.15	144.90

Table 5.2: Impact Test Results.

Samples	Load(Kg)	h_1(m)	h_0 - h_1(m)	mg(h_0- h_1)Nm
A	0.06	0.38	0.17	0.10
B	0.12	0.32	0.22	0.26
C	0.13	0.31	0.24	0.31
D	0.14	0.27	0.28	0.38
E	0.15	0.24	0.31	0.46

Table 5.3: Impact Strength Results

Sample	Impact strength (Kg/m)
A	0.16
B	0.38
C	0.42
D	0.52
E	0.63

Table 5.4: Weights of specimen for modulus test.

Sample	Weight (Kg)
A	0.0088
B	0.0115
C	0.0131
D	0.0145
E	0.0157

Table 5.5: Specimen A

Load (N)	Extension (mm)	Stress (N/mm^2)	Strain
400	2	0.444	0.04
700	4	0.778	0.08
1000	6	1.111	0.12
1300	9	1.444	0.18
1400	12.5	1.556	0.25

Table 5.6: Specimen B

Load (N)	Extension (mm)	Stress (N/mm^2)	Strain
200	1	0.222	0.02
300	2	0.333	0.04
400	3	0.444	0.06
540	5	0.600	0.10
600	6	0.667	0.12

Table 5.7: Specimen C

Load (N)	Extension (mm)	Stress (N/mm^2)	Strain
100	0.38	0.111	0.008
150	0.63	0.167	0.013
240	1.25	0.267	0.025
300	1.75	0.333	0.035

Table 5.8: Specimen D

Load (N)	Extension (mm)	Stress (N/mm^2)	Strain
200	0.75	0.222	0.015
300	1.25	0.333	0.025
480	2.5	0.533	0.050
530	3.75	0.589	0.075
600	6	0.667	0.120

Table 5.9: Specimen E

Load (N)	Extension (mm)	Stress (N/mm^2)	Strain
120	1	0.133	0.02
260	2	0.289	0.04
400	3	0.444	0.06
540	4	0.600	0.08
700	5.5	0.778	0.11

Slope of the stress-strain graph, which is an indication of the modulus of the various specimens, is got from the linear section of the graph and it is tabulated below.

Table 5.10: Young modulus

Specimen	Young Modulus
A	11.10
B	11.20
C	13.88
D	14.80
E	6.65

Appendix III

Figure 8: Specimen for impact strength test.

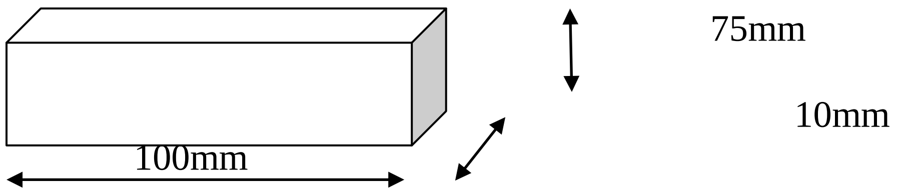

Figure 9: Specimen for Modulus test.