POLYMER COMPOSITES – EXERCISE No. 1			
Exercise Title: **POLYMER COMPOSITE - PREPARATION AND PROPERTIES OF POLYESTER LAMINATES**			
Faculty: Speciality:	CHEMICAL TECHNOLOGY Composites and Nanomaterials	Year: **I**	Term.: II

1. Objectives of the experiment:

theoretical – to get basics knowledge about the theory of obtaining polymer composites

practical – making an exemplary polyester laminate and testing its properties

2. Theoretical issues:

Composites (definition, types, properties), production of composites, types of binders and reinforcing materials for laminates, separating agents, construction of laminates and methods of their formation, advantages and disadvantages of thermoset and thermoplastic composites processing, use of laminates, environmental risk in the processing of composite products, testing the strength of laminates, flexure test, Young's module, commonly used fibers and resins in the thermoset composites industry, composite manufacturing techniques, function of a matrix in a composite material.

3. Literature:

1. Crawford R.J. : „Plastics Engineering”, Butterworth-Heinemann 1998.
2. Ram A.: “Fundamentals of Polymer Engineering”, Plenum Press, New York 1997.
3. Sanjay K. M. „Composites manufacturing Materials, Product and Process Engineering”, CRC Press, 2002

4. List of reagents:

a) resin C.E.S. R10X9
b) initiator Butanox LPT
c) cobalt accelerator
d) glass mat and glass fabric

5. Experimental part:

1. Preparation of polyester laminates

1.1. Investigation of the kinetics of copolymerization of unsaturated polyester resins

Investigate the kinetics of copolymerization by thermal method. Make three tests containing:

1. 35 g of resin + 1 wt.% accelerator + 1.5 wt.% initiator
2. 35g of resin + 2 wt.% accelerator + 1.5 wt.% initiator
3. 35g of resin + 4 wt.% accelerator + 1.5 wt.% initiator

Weigh the resin in the cup and then the accelerator. Mix thoroughly and set aside for about 5 minutes. During this time, prepare the thermocouple for measurement. Add the catalyst to the previously prepared composition, mix thoroughly, place the thermocouple at the height of ½ of the cup content. Read temperature every 10 sec. Repeat the measurement for other samples. Accelerator and initiator should be dosed to the system by volume (density 0.91 g/cm^3).

2. Obtaining a polyester-glass laminate - a plate for strength test

2.1. Preparation of the mold

The glass plate must be cleaned of residual resin and release agent. Using a clean cloth, apply the release agent to the mold surface and spread a thin layer. After drying (a few minutes), apply a second layer of release agent and wait for it to dry

2.2. Preparation of raw materials

Cut 3 pieces of glass fabric and 3 pieces of A5 glass mat.
Then, make two polyester-glass laminates containing the following systems of fabric and glass mat:

- 3 layers of glass fabric
- 3 layers of glass mat

and polyester resin (75g) prepared according to the recipe selected in the first part of the exercise (the recipe should be agreed with the teacher). Prepare the resin just before use. Apply a mat or fabric to the mold and saturate it with resin using a brush (or roller) until the air is removed from the mat/fabric being applied. Allow laminate to cross-link completely. After the resin has hardened, separate the finished laminate from the mold.

3. Strength properties of polyester laminates

3.1. Mechanical properties during flexure test

Laminates obtained earlier (by another group) should be used for strength tests.
Cut 6 strips 100mm x 10mm in size from the laminate board. Using a caliper, measure the thickness and width of the individual samples (average of a minimum of three measurements).
The mechanical properties of laminates should be assessed using the Zwick Roell Z020 TH ALLround Line universal testing machine. Perform tests of mechanical properties during flexure test in accordance with the standards:

- PN-EN ISO 178: 2011 – "Plastics. Determination of bending properties",
- PN-EN ISO 14125: 2001 – "Fibre – reinforced plastic composites – determination of flexural properties".

Test parameters:

- Initial force 0.2N,
- Room temperature,
- Load pattern: a sample bent in a three-point configuration to a deformation of 2 mm.

4. The report:

The report should describe the method of carrying out the exercise. Plot the temperature versus time for systems with different accelerator contents. In the table show the times and maximum temperatures achieved for each system. Write down the conclusions (the effect of accelerator addition on the kinetics of copolymerization).
Assess the quality of the produced laminate on the basis of the external appearance and the degree of saturation of the mat/fabric with resin. Provide the results of the experiment with standard deviations (in tabular form and in graphs), calculate the strength parameters of the tested laminate and write down the conclusions (the influence of the laminate structure on the tested strength parameters).

5. Safety rules:

I. All tests and measurements provided for in the exercise should be performed in accordance with the instructor's instructions.
II. To start the exercise, you must read the Material Safety Data Sheets (see appendix).
III. Take particular care when preparing the mixture of resin with accelerator and initiator, and when cutting samples for strength tests.
IV. Perform endurance tests only in the presence and supervision of the teacher.

6. Attachments:

a) Resin Safety Data Sheet C.E.S. R10X9
b) Cobalt Accelerator Safety Data Sheet (Cobalt 2-Ethylhexanoate)
c) Safety data sheet for the Butanox LPT initiator