Unit 134: Plastics Materials

Unit code: D/602/3458

QCF Level 3: BTEC National

Credit value: 10

Guided learning hours: 60

Aim and purpose

This unit enables learners to gain a knowledge of commodity and high performance plastics and an understanding of the importance of polymer morphology in predicting polymer properties. Learners will also develop practical skills and techniques through the laboratory investigation of flow and thermal behaviour of plastics materials.

Unit introduction

This unit builds on the concepts of plastics technology and provides an opportunity for learners to develop a knowledge of the properties and uses of commodity and high performance plastics. Learners also need to develop an understanding of the importance of the predictability of polymer properties and their effects on the environment and sustainability. Learners will gain an understanding of glass transition temperature, the factors that determine level of crystallinity, the concept of co-polymerisation, including the structures of different co-polymers and addition co-polymerisation. The unit provides opportunities for learners to explore practically the flow and thermal behaviour of plastics materials and develop their knowledge, skills and understanding through practical laboratory investigation using safe working practices.

Learning outcomes

On completion of this unit a learner should:

1 Know the properties and applications of commodity plastics and unsaturated polyester resins

2 Know the classification properties and applications of high performance plastics, epoxy and polyester composites

3 Understand the importance of polymer morphology in predicting polymer properties

4 Be able to investigate the flow and thermal behaviour of plastics materials.

Unit content

1 Know the properties and applications of commodity plastics and unsaturated polyester resins

Polyethene: structure; types; grading; processing properties; mechanical properties; cost; applications; decomposition

Polystyrene: structure; grading; processing properties; mechanical properties; cost; applications; decomposition

Polypropylene: structure; types; grading; processing properties; mechanical properties; cost; applications; decomposition

Polyvinylchloride: structure; types; additives; mixing techniques; processing properties; mechanical properties; cost; applications; decomposition

Acrylonitrile butadiene styrene: structure; types; grading systems; processing properties; mechanical properties; cost; applications; decomposition

Polyester resins (unsaturated): structure; types of resin; reinforcement materials; methods of processing eg hand lay-up, automated techniques; mechanical properties; cost; applications

Phenol formaldehyde resins: structure; resol and novolak; additives; laminating resins; moulding resins; processing properties; mechanical properties; cost; applications

Biodegradable plastics: Polyactide (PLA); polyhydroxyalkanoates (PHA); structure; costs; applications; decomposition

2 Know the classification properties and applications of high performance plastics, epoxy and polyester composites

Polymethylmethacrylate: structure; types; grading; processing properties; mechanical properties; cost; applications

Polyamides: structure; types; grading; additives; processing properties; mechanical properties; cost; applications

Polyacetal: structure; types; grading; processing properties; mechanical properties; cost; applications

Polycarbonate: structure; types; grading; processing properties; mechanical properties; cost; applications

Epoxy and polyester composites: structure; types; additives; reinforcing agents; mixing; processing; mechanical properties; cost; applications

3 Understand the importance of polymer morphology in predicting polymer properties

Glass transition temperature: factors that determine Tg; relate Tg to polymer performance; the Tg for commodity plastics; the Tg for high performance plastics; Tg values for different polymers

Crystallinity: factors that determine the level of crystallinity; relate crystallinity to polymer performance; rate the commodity plastics in terms of crystallinity; rate the high performance plastics in terms of crystallinity

Co-polymerisation: the concept of co-polymerisation; random, alternating, block and graft co-polymers; addition co-polymerisation; effect of co-polymerisation on polymer performance

4 Be able to investigate the flow and thermal behaviour of plastics materials

Flow behaviour: Newtonian; non-Newtonian; Bingham; pseudo-plastic and dilatent flows; shear rate; shear stress; apparent viscosity; orientation effects

Thermal behaviour: specific heat; viscosity temperature graphs; rate of cooling; shrinkage; residual stress; thermal stability of plastics during processing

Assessment and grading criteria

In order to pass this unit, the evidence that the learner presents for assessment needs to demonstrate that they can meet all the learning outcomes for the unit. The assessment criteria for a pass grade describe the level of achievement required to pass this unit.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P1 describe the properties of commodity plastics and unsaturated polyester resins [RL6]	**M1** explain the suitability of different commodity plastics for particular applications	**D1** analyse the cost of producing products using different commodity plastics
P2 describe the applications of commodity plastics and unsaturated polyester resins [RL6]		**D2** relate the structure of commodity and high-performance plastics materials to their physical properties
P3 describe the classification properties of high performance plastics, epoxy and polyester composites [IE4]	**M2** explain the suitability of different high performance plastics for particular applications	
P4 describe the applications of high performance plastics, epoxy and polyester composites [RL6]		
P5 explain the importance of polymer morphology in predicting polymer properties [IE3, IE4]	**M3** assess the factors that affect Tg and crystallinity	**D3** evaluate the effects of processing conditions on the mechanical properties of plastics materials
	M4 discuss the effect of co-polymerisation on the performance of a plastic material	**D4** analyse the effect of temperature changes, during processing and in-service, on plastics materials.

Assessment and grading criteria		
To achieve a pass grade the evidence must show that the learner is able to:	**To achieve a merit grade the evidence must show that, in addition to the pass criteria, the learner is able to:**	**To achieve a distinction grade the evidence must show that, in addition to the pass and merit criteria, the learner is able to:**
P6 carry out investigations into the flow and thermal behaviour of plastic materials, using safe working practices. [IE1, IE2, IE4, TW1, TW2, TW3, SM3]	**M5** distinguish between the types of flow apparent in plastic materials.	

PLTS: This summary references where applicable in the pass criteria, in the square brackets, the elements of the personal, learning and thinking skills. It identifies opportunities for learners to demonstrate effective application of the referenced elements of the skills.

Key	IE – independent enquirers CT – creative thinkers	RL – reflective learners TW – team workers	SM – self-managers EP – effective participators

Essential guidance for tutors

Delivery

The concepts covered by this unit should be delivered through a programme of tuition and practical laboratory work. Delivery should be based on a well-structured programme of practical exercises to develop learners' skills and the evidence necessary to meet the assessment and grading criteria. Learners should build on the concepts delivered in *Unit 45: Basic Polymer Technology*.

If it is appropriate to use facilities other than those in the centre (eg, facilities on employers' or university premises) arrangements to use those facilities should ensure that the necessary formative activities can be undertaken; one-off use of equipment will not meet the outcomes of this unit.

Health and safety should be a recurring theme throughout the delivery and assessment of this unit. Learners must be taught the nature of hazards and where to find appropriate information on them. Learners are not 'competent persons' under the COSHH regulations; they should not, therefore, be expected to carry out full risk analyses for practical work to be undertaken.

Outline learning plan

The outline learning plan has been included in this unit as guidance and can be used in conjunction with the programme of suggested assignments.

The outline learning plan demonstrates one way in planning the delivery and assessment of this unit.

Topic and suggested assignments/activities and/assessment
Introduction to unit.
Formal input: Properties and applications of commodity plastics and unsaturated polyester resins.
Demonstration showing different types of commodity plastics and unsaturated polyester resins and their applications.
Research on any listed properties.
Learners evaluate case studies on suitability of high performance plastics.
Learners carry out calculations of costs of producing products.
Learner initiated study on a sample of plastics and resins.
Assignment 1: Commodity Plastics and Unsaturated Polyester Resins (P1, P2, M1, D1)
Formal input: Properties and applications of high performance plastics including structures, gradings, processing properties.
Demonstration showing different types of high performance plastics.
Learners compare costs of high performance plastics.
Formal input: epoxy and polyester composites.
Assignment 2: High Performance Plastics (P3, P4, M2, D2)
Formal input: Glass transition temperature and crystallinity.

Topic and suggested assignments/activities and/assessment
Learners inspect transition temperature tables for different polymers.
Learners predict polymer properties.
Formal input: effects of processing on mechanical properties of plastics.
Formal input: structural types of co-polymers.
Learner self initiated study on co-polymers.
Assignment 3: Predicting Polymer Properties (P5, M3, M4, D3, D4)
Formal input: Flow and thermal behaviour of polymers.
Demonstration of behaviours.
Learners inspect data sheets on plastic materials.
Formal input and briefing on following practical procedures and safety.
Formative work on investigating thermal and flow behaviour.
Assignment 4: Flow and Thermal Behaviour of Plastic Materials (P6, M5)
Review of unit and results of assessment.

Assessment

The focus of assessment should be on learners carrying out the required tasks and producing evidence towards meeting the unit assessment and grading criteria. Tutors should observe learners undertaking practical activities and clearly record assessment decisions using an appropriate assessor's observation record, retained for audit purposes.

Safety requirements must be applied to all activities. Learners must work safely and accurately within supplied methods; this must be applied rigorously to all activities.

The pass assessment criteria require practical methods to be followed safely and correctly in order to investigate the properties and applications of commodity plastics and unsaturated polyester resins. Delivery of the unit should be based on the development of skills in industrially relevant methods to meet these criteria.

For the merit criteria, learners need to show appreciation of the benefits and drawbacks of a range of plastics for a variety of applications. This requires delivery of the underlying principles, which may be introduced before or during the practical work, but should be emphasised throughout the formative programme preceding assessed exercises.

The distinction criteria require investigation into the costs associated with plastic production and the effects of processing conditions on the mechanical properties of plastic materials. It may be appropriate to focus on one activity in detail as a group exercise. Thereafter, these activities may be left to independent study, with appropriate guidance from tutors. If group work is undertaken, tutors must ensure that each learner individually produces sufficient evidence to meet the assessment and grading criteria and that assessment decisions are clearly recorded using an appropriate observation sheet.

Programme of suggested assignments

The table below shows a programme of suggested assignments that cover the pass, merit and distinction criteria in the assessment and grading grid. This is for guidance and it is recommended that centres either write their own assignments or adapt any Edexcel assignments to meet local needs and resources.

Criteria covered	Assignment title	Scenario	Assessment method
P1, P2, M1, D1	Commodity Plastics and Unsaturated Polyester Resins	The marketing department request a chart of commodity and high performance plastics from the polymer chemist.	Chart. Illustrated article. Table.
P3, P4, M2, D2	High Performance Plastics		
P5, M3, M4, D3, D4	Predicting Polymer Properties	The British Plastics Federation has asked your company for an article on predicting polymer properties.	Article. Report.
P6, M5	Flow and Thermal Behaviour of Plastic Materials	The polymer chemist has asked you to report on the quality control of the latest batch of plastic materials.	Laboratory report.

Links to National Occupational Standards, other BTEC units, other BTEC qualifications and other relevant units and qualifications

This unit forms part of the BTEC Applied Science sector suite. This unit has particular links with the following unit titles in the BTEC Applied Science suite:

Level 2	Level 3
Chemistry and Our Earth	Basic Polymer Technology
Applications of Chemical Substances	Plastics Processing
	Polymer Process Engineering
	Scientific Practical Techniques
	Fundamentals of Science
	Industrial Applications of Organic Chemistry
	Industrial Chemical Reactions

Essential resources

Learners need access to appropriate laboratory facilities and specialist resources to cover the contextualisation of the underlying concepts to their polymer specialism eg plastics, rubber or related areas. Site visits to relevant industrial facilities to see practical techniques in operation would be invaluable. Input from industry experts as guest speakers would enhance unit delivery.

Employer engagement and vocational contexts

British Plastics Federation

Cogent – Sector Skills Council

Network for Science, Technology, Engineering and Maths – Network Ambassadors Scheme

The Polymer Society

Indicative reading for learners

Journals

British Rubber and Plastics

Materials Foresite

Materials World

Plastics, Rubber and Composites

Websites

www2.chemistry.msu.edu/faculty/reusch/VirtTxtJml/polymers.htm	Article on polymers including Tg, copolymers and crystallinity
www.bpf..co.uk	British Plastics Federation
www.cia.org.uk	Chemical Industries Association
www.cogent-ssc.com	COGENT – Sector Skills Council
www.en.wikipedia.org/wiki/polymers	Wikipedia
www.expainthatstuff.com/bioplastics.html	Bioplastics
www.iom3.org	The Institute of Materials, Minerals and Mining
www.iom3.org/content/polymersociety	The Polymer Society
www.practicalchemistry.org	Practical experiments on polymers
www.rsc.org.uk	The Royal Society of Chemistry
www.stemnet.org.uk	Network for Science, Technology, Engineering and Maths – Network Ambassadors Scheme

Delivery of personal, learning and thinking skills

The table below identifies the opportunities for personal, learning and thinking skills (PLTS) that have been included within the pass assessment criteria of this unit.

Skill	When learners are …
Independent enquirers	obtaining data and using results to predict properties
Team Workers	carrying out investigations
Reflective learners	communicating to different audiences
Self-managers	planning and completing experiments.