

<b>Title</b>	<b>Demonstrate knowledge of polymer property relationships, their structure and polymerisation</b>		
<b>Level</b>	<b>5</b>	<b>Credits</b>	<b>12</b>

<b>Purpose</b>	People credited with this unit standard are able to demonstrate knowledge of: polymerisation; polymer structure and its influence on polymer properties; modifications of plastics materials; test methods; and the properties and applications of polymers.
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<b>Classification</b>	Plastics Processing Technology > Plastics Materials
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<b>Available grade</b>	Achieved
<b>Recommended skills and knowledge</b>	<p>Unit 9708, <i>Explain the influence of polymer morphology on properties and processing of plastics materials.</i></p> <p>Knowledge of the following aspects of chemistry: atomic structure, molecular weight, periodic table, ionic and covalent bonding, intermolecular bonding, hydrogen bonding, structure of organic compounds, functional groups and typical reactions, saturated and unsaturated compounds, aromatic compounds, hydrolysis and addition reactions.</p>

### Explanatory notes

#### 1 Definitions

*Morphology* – the structure or architecture of polymer molecules and the way in which they arrange themselves in the solid state.

*Polymer composites* – two component plastic materials consisting of a polymer matrix and a continuous layered reinforcing media. The plastic materials are generally hand fabricated.

*Polymer reinforcements* – discontinuous reinforcing components distributed randomly in three dimensions throughout the polymer. The components are short fibres, particles, spheres and other shapes, and the plastic material is generally moulded.

### Outcomes and evidence requirements

#### Outcome 1

Demonstrate knowledge of polymerisation.

**Evidence requirements**

- 1.1 The mechanisms and conditions for addition (chain) polymerisation of polymers are described.
- Range mechanisms – free radical (initiation, propagation, termination), ionic;  
conditions – temperature, pressure, catalyst;  
polymers – polyolefins, polystyrenes, polyvinyl chlorides, and their copolymers;  
evidence is required for one polymer.
- 1.2 The typical production conditions for the industrial polymerisation of polyethylene are described.
- Range conditions – temperature, pressure, catalyst.
- 1.3 The mechanisms for condensation (step) polymerisation of polymers are described.
- Range polymers – polyesters, polyamides;  
evidence is required for one polymer.
- 1.4 The structures of both the monomer and polymer repeat unit (mer) for common polymers are described.
- Range common polymers – polyolefins, polystyrenes, polyvinyl chloride, polyesters, polyamides,  
evidence is required for three common polymers.
- 1.5 The effect of bulk, suspension, solution, and emulsion polymerisation methods on the processing and properties of addition polymers are described.
- Range addition polymers – polyvinyl chloride, polymethyl methacrylate;  
properties – particle size, size distribution, particle shape and porosity, clarity, molecular weight, electrical properties, heat stability;  
evidence is required for one addition polymer.
- 1.6 Molecular weight distribution and its dependence on polymerisation mechanisms and conditions are defined.
- Range molecular weight distribution – number average ( $M_n$ ) and weight average ( $M_w$ ).
- 1.7 The formation of cross-linked (networked) polymers is described.
- Range cross-linked polymers – unsaturated polyesters, polyurethanes;  
evidence is required for one cross-linked polymer.

**Outcome 2**

Demonstrate knowledge of polymer structure and its influence on polymer properties.

**Evidence requirements**

2.1 The tacticity of typical addition polymers are described.

Range tacticity – atactic, isotactic, syndiotactic;  
typical addition polymers – polypropylene, polyvinyl chloride, polystyrene;  
evidence is required for one typical addition polymer.

2.2 Copolymer structures are described.

Range copolymer structures – random, alternating, block, graft.

2.3 The influence of monomer structure on the chain regularity of branched and linear condensation and addition polymers is described.

Range condensation polymers – nylon 6.6, nylon 6, polyester, polycarbonate;  
addition polymers – low density and high density polyethylene, polypropylene, polyvinyl chloride, polystyrene, ethylene propylene, ethylene vinylacetate, polyacetal homopolymers and copolymers;  
evidence is required for one condensation polymer and one addition polymer.

2.4 The polarity of polymer molecules and the resulting intermolecular forces between polymers are described.

Range polymers – polyethylene, polyacetal, polyvinyl chloride, polyester, nylon 6.6, nylon 6.10;  
intermolecular forces – Van der Waal's forces, dipole-dipole interaction, hydrogen bonding;  
evidence is required for each type of intermolecular force.

2.5 The chain flexibility of polymers is compared in relation to chain regularity, tacticity, intermolecular forces and temperature.

Range polymers – low density and high density polyethylene, polypropylene, polyacetal, polyvinyl chloride, polystyrene, polyester, nylon 6.6, polycarbonate;  
evidence is required for four polymers.

- 2.6 The solid state properties of polymers are compared in terms of their molecular chain flexibility.
- Range polymers – low density and high density polyethylene, polypropylene, polyacetal, polyvinyl chloride, general purpose and high impact polystyrene, polyester, nylon 6.6, nylon 6.10, polycarbonate, thermoplastic elastomers;  
solid state properties – glass transition temperature, melting point, rigidity, tensile yield strength, softening point, transparency, barrier;  
evidence is required for all solid state properties and two polymers.
- 2.7 The influence of molecular weight and molecular weight distribution on the properties of polymers is described.
- Range properties – melt viscosity, impact strength, rigidity;  
polymers – polyethylene, polypropylene, nylon, polycarbonate;  
evidence is required for one polymer.
- 2.8 The influence of molecular orientation and degree of crystallinity on the barrier properties of polymers is described.
- Range barrier properties – oxygen, carbon dioxide, water;  
polymers – ethylene vinyl alcohol, polyvinylidene chloride, polyethylene, polypropylene, nylon, polyethylene terephthalate;  
evidence is required for one polymer.
- 2.9 The effect of crosslinking and the degree of crosslinking on the properties of polymers and elastomers are described.
- Range properties – rigidity, impact strength, flow properties, thermal stability;  
polymers – polyester, epoxy;  
elastomers – ethylene propylene diene monomer (EPDM), silicone;  
evidence is required for one polymer and one elastomer.
- 2.10 The degradation mechanisms and the degradation mechanisms of degradable polymers are described.
- Range degradation mechanisms – photo degradation, hydrolisation, biodegradation, thermal degradation, ultraviolet degradation, chemical degradation;  
degradable polymers – starch-based polymers, polyesters (polylactic acid and polyhydroxyalkanoate);  
evidence is required for a starch-based polymer and a polyester.

### Outcome 3

Demonstrate knowledge of modifications of plastics materials.

#### Evidence requirements

- 3.1 The structures of polymer reinforcements and polymer composites are distinguished.
- 3.2 Polymer reinforcements and their influence on plastics materials properties are described and compared.
- Range polymer reinforcements – particles, beads, fibres;  
properties – tensile strength at yield, modulus, dimensional and thermal stability;  
evidence is required for two polymer reinforcements.
- 3.3 The typical formulations and an application for polymer reinforced materials are described.
- Range polymer reinforced materials – glass reinforced nylon, glass reinforced polypropylene, talc reinforced polypropylene;  
evidence is required for one polymer reinforced material.
- 3.4 The failure mechanisms for reinforced plastics materials are described.
- Range failure mechanisms – brittle and ductile failure.
- 3.5 Copolymers, blends or alloys, and interpenetrating networks (IPN) are distinguished and the purpose for their use is explained.
- 3.6 The purpose of polymer compatibilisers is described.

### Outcome 4

Demonstrate knowledge of test methods.

#### Evidence requirements

- 4.1 The principles and purpose of analytical test methods are described.
- Range test methods – Fourier Transformation Infrared Spectroscopy (FTIR), Differential Scanning Calorimetry (DSC);  
evidence is required for one test method.

4.2 The principles, purpose, and limitations of test methods and the dependence of the results on polymer morphology and additives are described.

Range electrical test methods – dielectric constant, power factor, volume resistivity, surface resistivity, tracking resistance;  
 optical test methods – haze and clarity, reflectance;  
 environmental test methods – UV, environmental stress crack resistance (ESC), weatherometer;  
 barrier test methods – moisture vapour transmission rate (MVTR), carbon dioxide transmission rate, oxygen transmission rate;  
 thermal test methods – Vicat softening temperature, heat distortion temperature (HDT), specific heat, coefficient of thermal expansion, thermal conductivity, flammability, low temperature brittleness;  
 mechanical test methods – tensile, creep, coefficient of friction, wear resistance;  
 evidence is required for one type of each of the three different test methods.

4.3 The principles of colour measurement using colour coordinates (Lab) and colour difference are described.

**Outcome 5**

Demonstrate knowledge of the properties and applications of polymers.

**Evidence requirements**

5.1 The properties of typical polyethylene grades are compared and contrasted in relation to their morphology, product applications, and processing methods.

Range properties – density, glass transition temperature, flow properties, melting point, specific heat, clarity, rigidity, tensile strength, impact strength, crystallinity, ESC;  
 evidence is required for four properties.

5.2 The properties of polymers are compared and contrasted in relation to their morphology, product applications, and processing methods.

Range properties – mechanical, electrical, chemical, processing;  
 polymers – polyamides, acrylics, fluoropolymers, polycarbonates, polyphenylene oxides, acetals, polyesters, homopolymers and copolymers of polyolefins, vinyls and styrenes;  
 evidence is required for two properties and two polymers.

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<b>Planned review date</b>	31 December 2021
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**Status information and last date for assessment for superseded versions**

Process	Version	Date	Last Date for Assessment
Registration	1	27 May 2002	31 December 2019
Rollover and Revision	2	25 September 2006	31 December 2019
Review	3	11 December 2009	31 December 2019
Review	4	15 September 2016	N/A

<b>Consent and Moderation Requirements (CMR) reference</b>	0013
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This CMR can be accessed at <http://www.nzqa.govt.nz/framework/search/index.do>.

**Please note**

Providers must be granted consent to assess against standards (accredited) by NZQA, before they can report credits from assessment against unit standards or deliver courses of study leading to that assessment.

Industry Training Organisations must be granted consent to assess against standards by NZQA before they can register credits from assessment against unit standards.

Providers and Industry Training Organisations, which have been granted consent and which are assessing against unit standards must engage with the moderation system that applies to those standards.

Requirements for consent to assess and an outline of the moderation system that applies to this standard are outlined in the Consent and Moderation Requirements (CMR). The CMR also includes useful information about special requirements for organisations wishing to develop education and training programmes, such as minimum qualifications for tutors and assessors, and special resource requirements.

**Comments on this unit standard**

Please contact Competenz [qualifications@competenz.org.nz](mailto:qualifications@competenz.org.nz) if you wish to suggest changes to the content of this unit standard.