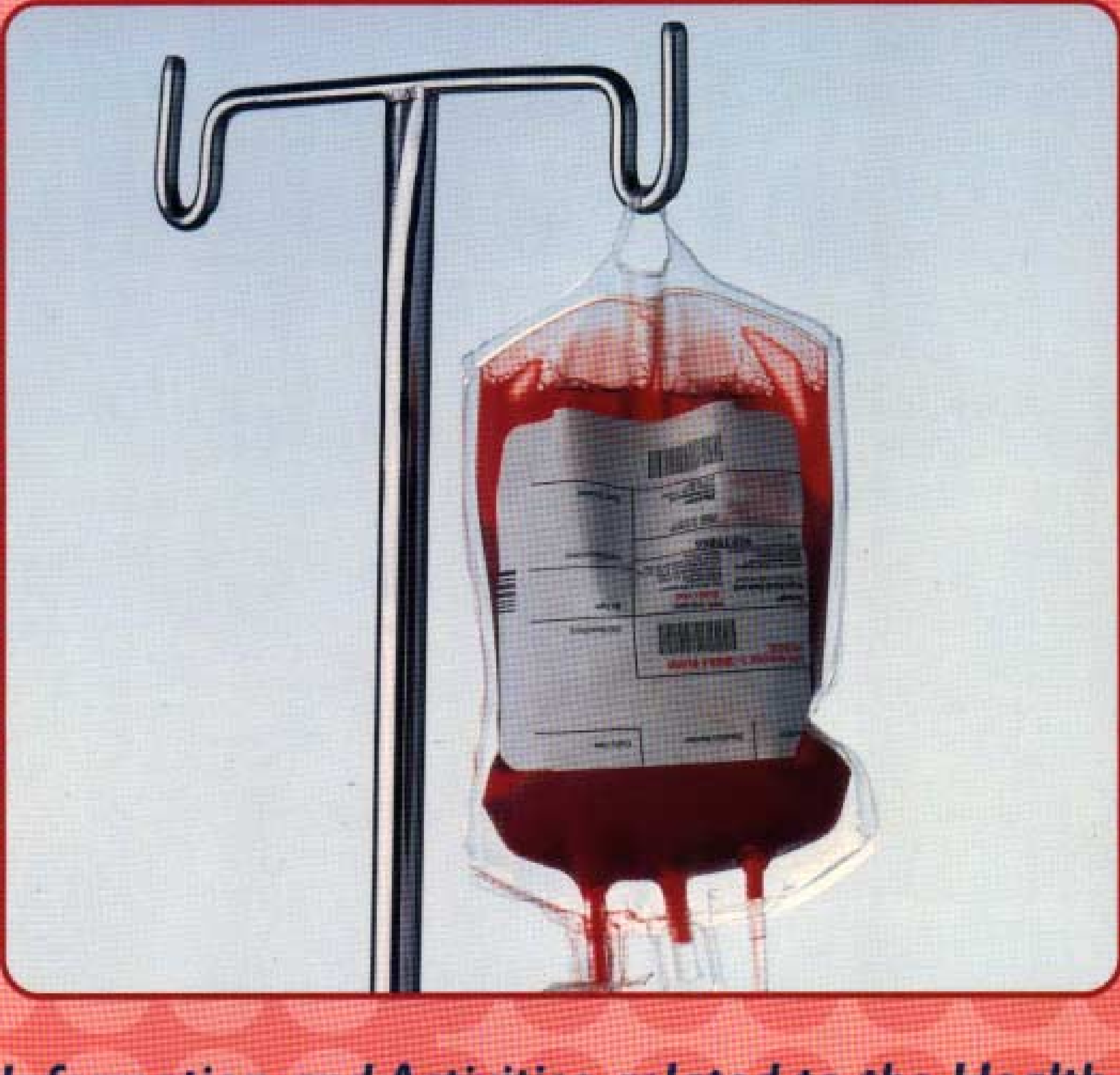
CHEMICALS FOR HEALTHY LIFE

EMERGENCY CARE:

blood bags and tracheal tubes



Information and Activities, related to the Health-care Industries, for Post-16 Science Courses

CIEC

Hydro Polymers

EMERGENCY CARE:
blood bags and tracheal tubes

Information and Activities
for Post-16 Science Courses

Advanced GNVQ Science	AS & A level Chemistry and Physics	BTEC National Diploma Health Science	Project work Chemistry and Physics

CHEMICALS FOR HEALTHY LIFE is a series of resources which use contexts from the health-care industries to introduce post-16 students to science concepts and to the work of people within these industries. The resources are packaged in a form which enables teachers to select activities and supporting resources to suit their courses. The student task sheets in the resources can be accessed on the internet so that they can be modified easily to suit particular students.

This resource has been prepared by John Lazonby and is based on research and development by Brian Ratcliff, Long Road Sixth Form College, Cambridge
and John Baldwin, Hydro Polymers, Newton Aycliffe, Co. Durham.

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CHEMICALS FOR HEALTHY LIFE
EMERGENCY CARE:
blood bags and tracheal tubes

CONTENTS OF THE RESOURCES

CHEMICALS FOR HEALTHY LIFE EMERGENCY CARE: *blood bags and tracheal tubes*

CONTENTS OF THE RESOURCES

This resource pack is one of a series published by the ***Chemicals for Healthy Life*** project to support post-16 science courses, particularly Advanced GNVQ Science.

Each pack provides the following **resources for students**:

Introducing Sheet	Ten copies of this full-colour, folded A3 sheet are provided. It describes the 'place of work' context and so justifies the student tasks. It also aims to illustrate how the particular industry and its products are important to the students' lives and the lives of others.

Where appropriate each task is supported by the following photocopiable resources printed on white paper:

Task Sheet	This outlines the task and indicates which other sources students may need to study. These sheets are available on the internet, http//www.york.ac.uk/org/ciec so they can be edited easily to cater for the needs of your students and to clarify the specific evidence you wish them to produce.
Data Sheets	These supply data required for the task.
Science Ideas and Techniques Sheets	These help students to research and develop a knowledge of an experimental technique and/or an understanding of the underlying science. For some students these could be used as the starting point for their own research, for others they can be used as support for class teaching of the topics. Some of these sheets will help students prepare for particular items on the GNVQ unit test.

There are also **resources for teachers:**

Teacher's Notes (printed on pink paper)	These provide notes to help with curriculum planning, on safety issues and on each task. Where appropriate, indications of possible outcomes of tasks and answers to problems are given.

How you could use these resources

Advanced GNVQ

They are intended to be useful additions to the resources you have available to support your programme of work for GNVQ. The complete package can be kept in a ring binder and you can select from the student resources those sheets which you wish them to use and so create separate student files. The following pages identify each separate student resource and indicate how each task contributes to the GNVQ coverage and provides opportunities for students to produce required evidence.

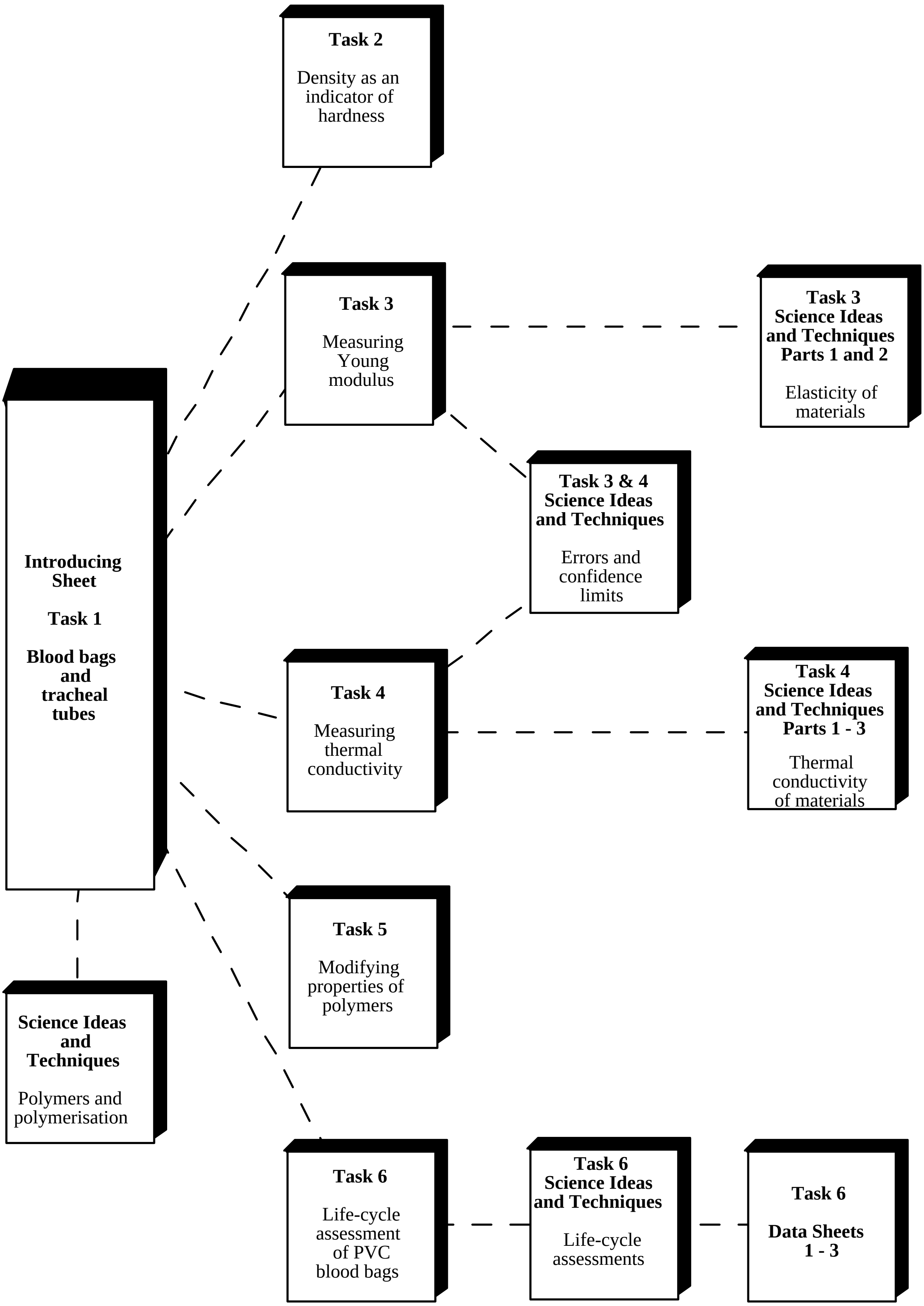
AS and A level

The activities provide opportunities for students to relate the concepts and techniques covered to industrial contexts. The contexts can also be used as the starting points for investigations and project work. Task 6 will be particularly useful for courses which consider the environmental implications of science.

Health Science

The *Introducing Sheet* can be used as the starting point for a selection of the activities for students following courses such as the BTEC National Diploma.

CHEMICALS FOR HEALTHY LIFE
EMERGENCY CARE
Student resources
- each box represents a separate resource sheet



GNVQ coverage

In this pack, teacher and student resources are provided for tasks related to the context of the use of PVC for making blood bags and tracheal tubes. The resources support activities which would allow students to satisfy the performance criteria and produce the evidence indicators, using polymers as the chosen material, required for the materials unit of the Advanced GNVQ in Science. In some of the activities there are opportunities for students to investigate the use of glass as an alternative material from which to make containers for blood. The supporting resources will help students develop an understanding of the scientific ideas underpinning the activities.

Performance criteria covered by each task.

			Task/Performance criteria					
		Science Element	**1**	**2**	**3**	**4**	**5**	**6**
	2.1	Identify the properties of materials for particular uses	1-4	1-4				1-4
	2.2	Determine the physical properties of materials		1-4	1-4	1-4		
	2.3	Modify materials to make them more useful					1-4	
	8.1	Gather, process and evaluate scientific data		3-6				

		Key Skills Elements						
N	3.1	Collect and record data			1-7	1-9		
U	3.2	Tackle problems			1-7	1-9		
M	3.3	Interpret and present data						

C	3.1	Take part in discussions	1-5					1-5
O	3.2	Produce written material	1-5					1-5
M	3.3	Use images						1-3
	3.4	Read and respond to written materials						1-4

	3.1	Prepare information		1-5				
I	3.2	Process information						
T	3.3	Present information						
	3.4	Evaluate the use of information technology						

Science ideas and techniques

The table below summarises the main science ideas and techniques which students are either assumed to know or expected to develop an understanding of during the unit.

Assumed knowledge	Knowledge developed or revised
• molecules • covalent bonding and the conventional representation of structural formulae of molecules • differences in melting points can be related to differences in the attractive forces between particles in solids • explanations of the physical properties of materials can be developed from a knowledge of their structures at an atomic or molecular level	• polymers and polymerisation: -addition and condensation polymerisation • properties of polymers in relation to their uses • physical properties of polymers related to: -thermoplastic and thermosetting -cross-linking -cold drawing -elastomers, plastics and fibres -additives such as plasticisers • measurement of physical properties: -density -Young modulus -thermal conductivity • identification of sources of error and the estimation of confidence limits • life-cycle assessment as a method of investigating the environmental impact of using a material for a particular function

Science evidence indicators arising from each task

ELE		EVIDENCE INDICATORS	TASKS AND OPPORTUNITIES TO PRODUCE EVIDENCE INDICATORS 1	2	3	4	5	6
2.1	2 REPORTS	2 different materials from the range (metal,ceramic,**polymer** & composite) to include three points	✓	✓				✓
2.2	3 REPORTS	Young modulus			✓			
		refractive index						
		thermal conductivity				✓		
		to include sources of error & confidence limits						
	NOTES	physical properties explained by material structure			✓	✓		
	REPORT	measurement in an industrial lab			✓	✓		
2.3	2 REPORTS	modifying 2 materials from the range changes in prop. linked to structure 1 carried out by the student					✓	
	PRESENTATION	an industrial process to modify material					✓	
8.1	RECORD	data from 4 investigations						
		biological context						
		chemical context						
		physical context		✓				
		primary data checked against published data		✓				
	RECORD	data						
		manually processed		✓				
		electronically processed		✓				
		using formulae						
		using graphs		✓				
	STATEMENT	conclusion consistent with data, related to purpose and sources of error		✓				

CHEMICALS FOR HEALTHY LIFE EMERGENCY CARE: *blood bags and tracheal tubes*

PRE-PLANNER

Plastics/Polymers is a comprehensive directory of sources of information available from industry to schools and colleges. It is published by Schools Polymer Information Service, CIEC, Department of Chemistry, University of York, York, YO10 5DD.

A selection of the resources listed below would enable students to carry out their own literature research to support their work on the activities in this pack.

Resource	Available from
British Plastics Federation, (1996) *PVC EXPLAINED*, BPF. BPF Fact Sheets, include: *Plastics in our lives* *PVC Bottles* *The above resources, including a History of Plastics, is available free to download on the internet.*	The British Plastics Federation, 6 Bath Place, Rivington Street, London EC2A 3JE Tel: 0207 457 5000 Fax: 0207 457 5045 Web: http://www.bpf.co.uk
Chemical Industry Education Centre, relevant publications include: *Dental Dilemmas, A GNVQ Resource* *Plastics a guide to some workshop practices and industrial processes* *Polymers physical testing* *The Essential Plastics Industry* *The Essential Chemical Industry* *Green Chlorine*	Chemical Industry Education Centre, Department of Chemistry, University of York, Heslington, York, YO10 5DD Tel: 01904 432523 Fax: 01904 434078 Web: http://www.ciec.org.uk Email: ciec@york.ac.uk
Chemistry Review A magazine for post-16 science students which contain many useful articles. For example, to support work on: plasticisers see Vol 4, No 5, 18-20 cross-linking see Vol 4, No 2, 20-24.	Philip Allan Publishers, Market Place, Deddington, Oxfordshire, OX15 0SE Tel: 01869 338652 Fax: 01869 338803
Emsley, J. (1994) *The consumer's good chemical guide*, W.H. Freeman, Oxford Chapter 6, *PVC* Chapter 7, *Dioxins, the world's deadliest toxins?*	W.H. Freeman & Co. Ltd., 20 Beaumont Street, Oxford, OX1 2NQ Web: http://www.whfreeman.com
European Council for Plasticisers and Intermediates, (1997) *Information Fact File*, ECPI.	ECPI UK representative, Paul Brown, BP Chemicals Ltd., Saltend, Hull, HU12 8DS Fax: 01482 894868 Web: http://www.ecpi.org

Greenpeace, (1996) *Taking back our stolen future, Hormone disruption and PVC plastic,* Greenpeace International. Greenpeace, (1993) *Dioxin Factories,* Greenpeace International Greenpeace, *What's wrong with PVC?* is available free to download on the internet.	Greenpeace UK, Canonbury Villas, London, N1 2PN Tel: 0207 865 8100 Fax: 0207 865 8200 Web: http://www.greepeace.org.uk Email: info@uk.greenpeace.org
Institute of Materials, Minerals & Mining Schools Affiliate Scheme, including free resource materials, details on the internet: http://www.iom3.org/education/sas.htm	The Education Department, Institute of Materials, Minerals & Mining 1 Carlton House Terrace, London SW1Y 5DD Tel: 0207 451 7300 Fax: 0207 839 1702
Norsk Hydro, (1992) *PVC AND THE ENVIRONMENT*, Norsk Hydro, Oslo, Norway. Norsk Hydro, (1996) *PVC AND THE ENVIRONMENT 96*, Norsk Hydro, Oslo, Norway.	Hydro Polymers Ltd., School Aycliffe Lane, Newton Aycliffe, Co. Durham, DL5 6EA Tel: 01325 300555 Fax: 01325 300215 Web: http://www.hydropolymers.co.uk
Salters Advanced Chemistry *Chemical Storylines* *Chemical Ideas* *Activities and Assessment Pack* Particularly the unit *The Polymer Revolution*	Heinemann Educational Publishers, FREEPOST (OF1771) PO Box 381 Oxford, OX2 8BR Tel: 01865 314333 Fax: 01865 314091 Web: www.heinemann.co.uk Email: orders@heinemann.co.uk
Shell Education Service in collaboration with CIEC, University of York *About Plastics* A pack of three booklets designed for 14-16 science and technology students but also suitable for post-16 students.	Shell Education Service, Shell International, Shell Centre SN1 7NA Web: http://www.shell.com
Philip Harris Education has an online catalogue available for teachers.	Philip Harris Education Findel House, Excelsior Road Ashby Park Ashby de la Zouch Leicestershire, LE65 1NG Web: http://www.philipharris.co.uk Email: sales@philipharris.co.uk

CHEMICALS FOR HEALTHY LIFE
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TEACHER'S NOTES

Safety

Although GNVQ Science courses require students independently to plan many of their activities, the responsibility for safety in their practical work still lies with the teacher/tutor who is in change of the students. It is assumed that the following apply.

1 A risk assessment will exist for all practical activities. This will have been prepared by the teacher/tutor, or by the student and checked by the teacher/tutor.
2 Plans produced by students for practical activities will be checked by the teacher/tutor.
3 Practical work is conducted in a properly equipped and maintained laboratory.
4 Any mains operated equipment is properly maintained. Any appliances brought in from outside the school or college are safety checked using the employer's Portable Appliance Testing programme before use.
5 Any fume cupboard operates at least to the standard of DES Design Note 29, *Fume Cupboards in Schools,* (1982), HMSO.
6 Rules for student behaviour are strictly enforced.
7 Eye protection is worn whenever there is a recognised risk to the eyes.
8 Care is taken with normal laboratory operations such as heating substances and handling heavy objects.
9 Good laboratory practice is observed when chemicals, living organisms and materials of living origin are handled.
10 Students are taught techniques that minimise risks for such activities as pouring chemicals, heating or smelling chemicals, and for handling micro-organisms.
11 Fieldwork takes account of any guidelines produced by the employer.

Risk Assessments

Risk assessments should be prepared using the General Risk Assessments in published documents, modified as appropriate to suit local circumstances. The following are important sources of information:

DfEE, (1996), *Safety in Science Education,* London: HMSO
ASE, (1996), *Safeguards in the School Laboratory (10th Edition),* Hatfield: Association for Science Education
ASE, (1988), *Topics in Safety,* Hatfield: Association for Science Education
CLEAPSS School Science Service, (1989), *Hazcards,* Uxbridge: Brunel University
CLEAPSS School Science Service, (1989), *Laboratory Handbook,* Uxbridge: Brunel University
SSERC, (1991), *Preparing COSHH Risk Assessments for Project Work in Schools,* Edinburgh: Scottish Schools Equipment Research Centre
HMI, (1993), *Microbiology: An HMI Guide for Schools and Further Education,* London: HMSO

The DfEE (1996) publication provides guidance on safety and on the legal position, detailed notes on a wide range of specific hazards and an extensive bibliography. This publication stresses the need for risk assessments to be part of the documentation in daily use rather than on forms which may "not be consulted regularly" and "are not likely to be modified when an activity is changed".

GNVQ students have to prepare risk assessments as part of the evidence indicators for Element 1.1 and this provides the opportunity to establish the practice of using risk assessments as working documents which are integral to each practical activity and which need to be modified as plans are modified. The student task sheets stress that they have to prepare risk assessments for their plans and have them checked by their teacher before starting practical work, and that if they modify their plan they should consider whether or not the risk assessment needs modifying.

It seems likely that students will find this easier if they adopt a standard approach to assessing risk. One possibility, based on that used in the individual investigation in *Salters Advanced Chemistry, Activities and Assessment Pack,* Heinemann, is to work through the following steps.

1 List all of the chemicals (approximate quantities and, when in solution, concentrations), items of equipment and operations to be used.

2 Identify and note the hazards associated with the chemicals, equipment and operations.

3 Note the precautions which they plan to take when using hazardous substances and equipment and when carrying out hazardous operations.

Naming monomers, polymers and additives
When students read publications from industrial or environmental organisations they are likely to meet some examples of non-systematic names for monomers, polymers and additives. In some cases these substances are known by acronyms based on these non-systematic names and so in this resource some non-systematic names are used. Where this is done the systematic name is also given when the name is first used within the student resources supporting a particular task.

Introducing Sheet
This sheet establishes the context for the activities. It emphasises the contribution of PVC to health care, outlines how it is made, its properties and how they are modified. It establishes the need for polymer technologists to be able to modify and measure the properties of different PVC formulations and so provides the background to ensure that the tasks which follow are seen as tackling problems which are typical of those faced by people working in this industry.

It would be useful if students could read and discuss the sheet and do Task 1 (the instructions for which are given on the sheet) in small groups. If students need to check their knowledge of polymers they are referred to the Science Ideas and Techniques Sheet - Introducing polymers and polymerisation. This sheet outlines some of the main ideas used to explain the characteristics of polymers and the differences between different polymers.

Tasks 2-6, each of which are supported by separate task sheets, are cross-referenced at appropriate points on the Introducing Sheet so as to emphasise their links with the work of people in the PVC industry.

Task 1
Blood bags and tracheal tubes
This task requires students to consider the properties of PVC and alternative materials, such as glass for blood containers and rubber tubing for tracheal tubes. At this stage their response to the task may be based solely on a consideration of the advantages and disadvantages of the PVC equipment in use. Task 6 provides guidance and data to enable them to attempt a more complete life-cycle assessment of PVC when used to make blood bags. You may wish to encourage students not to do too much additional research for Task 1 at this stage but to refer back to their Task 1 notes when they work on Task 6. It is recommended that they work on Task 6 when they have acquired more background knowledge and experience of PVC.

Their discussions may cover the following points.
Blood bags
Purposes: Blood bag used for collection and storage of blood. Bag and tube used for delivery during transfusion.

Conditions of use: Blood taken from a cold store will require warming to body temperature in order to remove any risk of hypothermia. Biochemicals in blood may interact with the bag or tube material. Other components in bag or tube material may affect the blood (plasticiser may migrate into the blood from PVC).

Further information for teacher: The PVC plasticiser di-(2-ethylhexyl) phthalate (DEHP) (sytematic name di-(2-ethylhexyl)benzene-1,2-dioate) has been shown to actually improve the storage life of the red blood cells. DEHP has however caused some concern as it has been shown to cause tumours in rats and mice when fed large quantities (equivalent to 500 g per day in human terms), however, this effect in rodents arises from a biochemical process in rodent livers which does not occur in humans. *Data Sheet 6.3* includes additional information on this. Other polymers used to make blood bags may also contain additives which leach into blood (e.g. anti-oxidants in the polyalkenes).

Alternative materials: glass was used prior to PVC bags and rubber tubing prior to PVC tubing. Polyalkenes have been used instead of PVC for the bag.

Advantages of PVC: Used containers can be disposed of after a single use by incineration. There are European Union regulations for specialist incinerators. As explained on the Introducing Sheet, low-cost single usage devices avoid cross-contamination. Glass bottles require sterilisation before re-use.

Further information for teacher: Glass has significant interactions with blood components. Very clean glass is surface active and may encourage blood clotting. Single use of PVC for blood bags and tracheal tubes is more economic over a full life-cycle assessment. This will be covered during the life-cycle assessment in Task 6.

Tracheal tubes
The photograph on the Introducing Sheet shows a modern tracheal tube. It is used during surgery to ensure a clear airway to the lungs and is inserted either through the nose or via the mouth. The version shown has an inflatable cuff which allows it to sit comfortably in the trachea and prevents fluids entering the lungs. The cuff is inflated through an airline in the wall of the tube. It is inflated via a one-way valve attached to a small balloon. This second inflatable section will deflate if there is a leak between the valve and the cuff.

Further information for teacher: The ease of manufacturing the tracheal tube from PVC is an important factor. The tube is made of a fairly stiff PVC blend. (density about 1240 kg m^{-3}, see Task 2 for the relationship between density and hardness).

The inflatable cuff and monitor balloon are made of a very soft, flexible PVC blend (density about 1200 kg m^{-3} or less).

A medium soft medical tubing would be suitable for the airline to the monitor balloon.

The connector is rigid PVC. All components which need to be heat formed, shaped or welded have a lower softening point (and lower cold flex temperature) to facilitate this process.

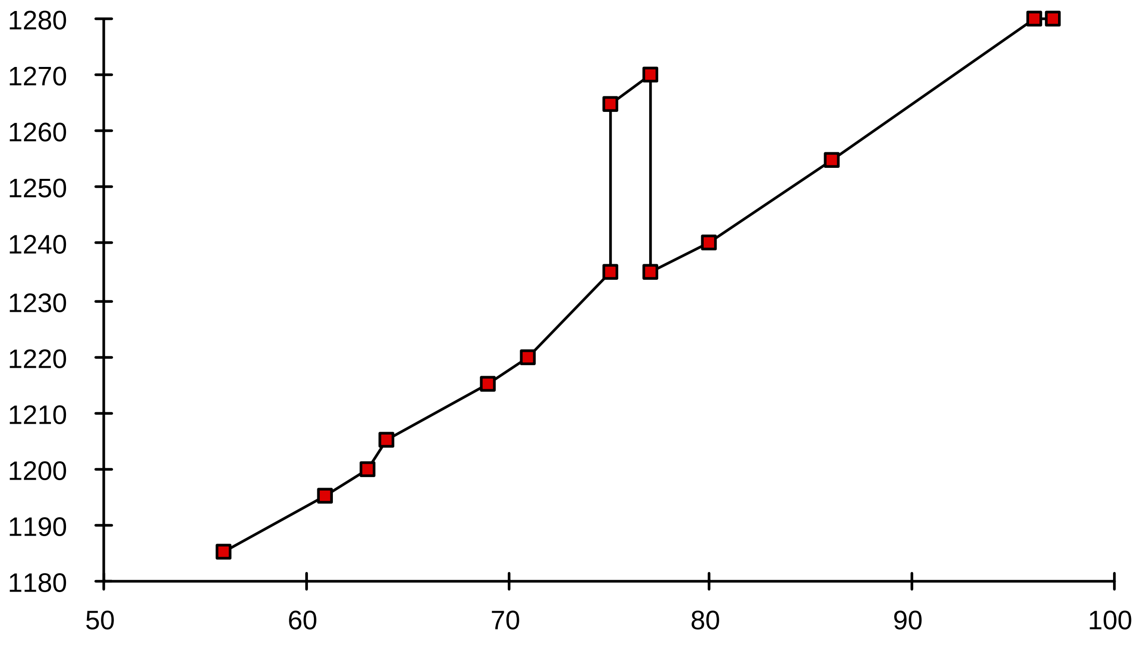
The external airline is solvent-welded to the internal one using tetrahydrofuran.

Task 2
Density of samples of PVC as an indicator of their hardness
Students should obtain a graph like the graph given below, from which they will see that the two extraction-resistant blends do not follow the pattern for the remaining blends.

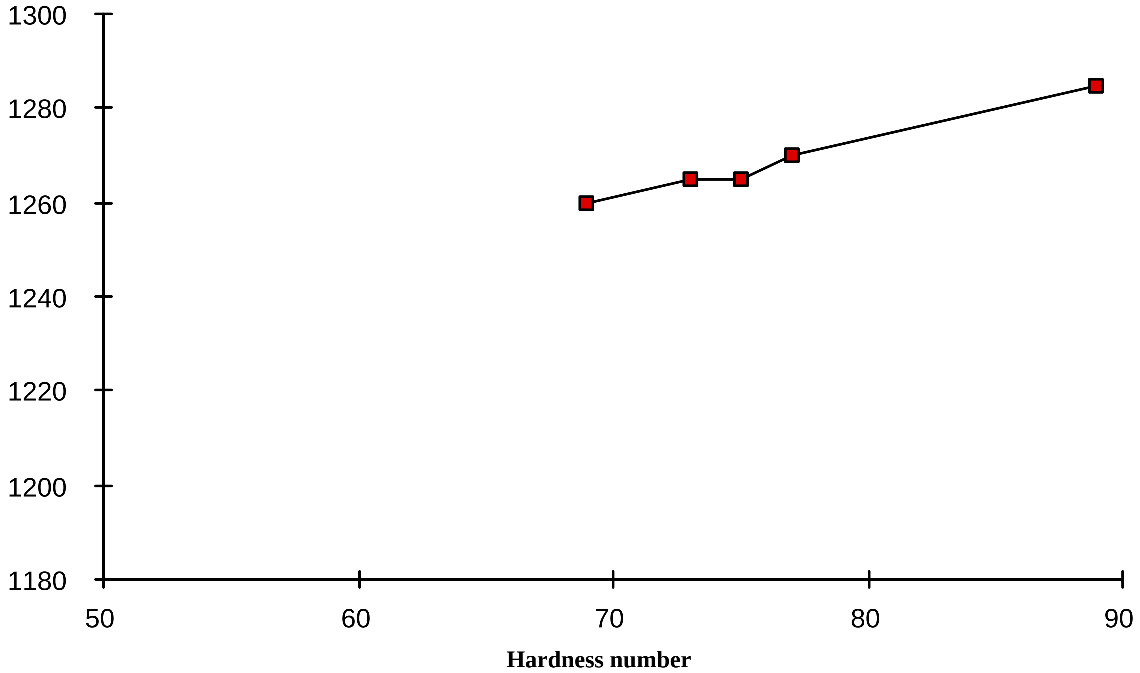
When the data from these two blends are put together with the additional data for three other extraction-resistant blends of PVC, they should obtain a graph like the extraction-resistant graph shown overleaf.

They can conclude that there is direct relationship between density and hardness for potentially-extractable PVC blends and a different, but still direct relationship for the extraction-resistant blends.

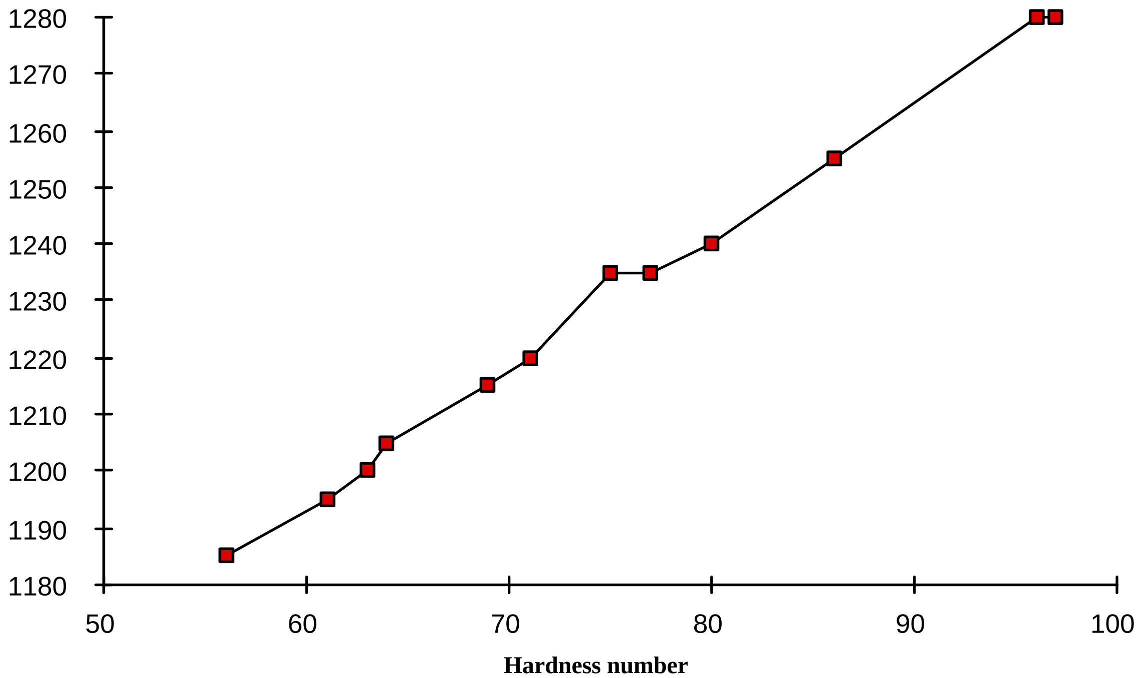
Density of PVC medical blends against hardness



Density of extraction resistant PVC against hardness



Density of potentially extractable PVC against hardness



Task 3
Measuring the Young modulus of samples of polymers
In addition to the *Task Sheet* this activity is supported by:

Task 3 Science Ideas and Techniques Sheet, Elasticity of materials.

Part 1 introduces Young modulus. The solution to the problem given to check their understanding is 38 mm.

Part 2 describes the equivalent industrial method for investigating the elasticity of materials. In this method the extension of the material is the independent variable and the tension is the dependent variable, whereas in the method used by the students they will apply various loads and measure the resulting extension.

Tasks 3 and 4 Science Ideas and Techniques Sheet, Errors and confidence limits.

This provides an introduction to uncertainties or experimental errors in measurements and how to combine them to estimate the error in the value of the quantity calculated from these measurements. Standard deviation is mentioned briefly in a separate box and it may be appropriate for some students to omit that part of the sheet. The answers to the questions given to check understanding are:

1 (a) 99.10 ± 0.05 °C, 84.50 ± 0.05 °C

(b) 99.15 - 84.45 = 14.7 °C

(c) 99.05 - 84.55 = 14.5 °C

(d) 14.6 ± 0.1 °C

2 (a) percentage error in original length = 0.5 %
percentage error in the extension = 4.0 %

(b) percentage error in the tensile strain = 4.5 %
the confidence limits for the tensile strain are 0.120 ± 0.005

Task 4
Measuring the thermal conductivity of samples of polymers
In addition to the *Task Sheet* this activity is supported by:

Task 4 Science ideas and Techniques Sheet, Part 1 - Thermal conductivity of materials, which introduces the principles of thermal conductivity. The answers to the problems given to check understanding are:
1 2000 J s^{-1}
2 314 W

Part 2 provides instructions and explanation of Lee's disc method of measuring the thermal conductivity of a poor conductor.

Part 3 describes the industrial method for measuring thermal conductivity which is based on the Lee's disc approach.

These sheets will help students prepare for Unit 2 Test specifications 4 and 5.

If students are not familiar with errors and confidence limits they should also work through *Task 3 and 4 Science Ideas and Techniques Sheet, Errors and confidence limits*, see the notes on this sheet given under Task 3 above.

Task 5
Modifying the properties of polymers

Cross-linking is not directly relevant to PVC. The pure polymer is rigid and a common modification is to add plasticisers to make it more flexible. However, to complete the coverage of the polymer section of the GNVQ specifications students could be encouraged to read the Chemistry Review article and make notes and/or do the cross-linking activity in *Salters' Advanced Chemistry*, *Activities and Assessment Pack*, Heinemann, Activity PR2.2, p 121.
Cold drawing can be demonstrated with supermarket bags, but is most impressive with undrawn nylon.

Plasticiser migration is referred to on the *Introducing Sheet*, by implication when extraction resistant blends are referred to in Task 2 and in more detail again in Task 6 when considering the environmental impact of producing, using and disposing off PVC blood bags. Plasticiser migration has to be considered very carefully in medical applications and so it is relevant to the context of blood bags. For the investigation, PVC floor tiles can be used to provide the test samples of PVC. DIY stores tend to sell self-adhesive tiles which is an added complication, but it is usually possible to obtain tiles without adhesive from flooring specialists. If you wish to maintain the emphasis on flexible PVC and so keep the link with context of blood bags, samples from heavy duty garden refuse sacks can be used for the investigation. Changes in the behaviour of the material under tension can be detected after
3 - 4 weeks contact with vegetable oil.

Task 6
A life-cycle assessment of PVC

This task lends itself to team planning, independent research and reporting back activities. In addition to the *Task Sheet* it is supported by:

Task 6 Science Ideas and Techniques Sheet, Life-cycle assessments which discusses what ideally should be involved in life-cycle assessments.

Data Sheets 6.1, 6.2 and 6.3 provide sufficient data for students to begin to appreciate the potential value and importance of life-cycle assessments and also how difficult it must be to do a comprehensive assessment. For some students these sheets could be the starting points for their own research. PVC has been used in medical applications for over forty years and has been the focus of much research and debate. This means that it is relatively easy to collect a set of resources which students could research themselves. Some relevant resources are listed in the *Pre-planner* on page 5.

EMERGENCY CARE:

blood bags and tracheal tubes

A tracheal tube is used during surgery to ensure a clear airway to the lungs. It is inserted either through the nose or via the mouth. This photograph shows a modern tracheal tube made from PVC.

This pack is concerned with the work of people who develop and test different blends of poly(vinyl chloride), PVC, for use in medical equipment such as blood bags and tracheal tubes. This Introducing Sheet will help you to appreciate the important role of PVC in health care, how the plastic is made and how the tasks you do later relate to those undertaken in industry. The instructions for Task 1 are given below, whereas Tasks 2-6 which follow are cross-referenced on this sheet so as to emphasise their relevance.

Advances in health care are not solely associated with the development of our understanding of illnesses and new drugs to treat them. Other important advances arise from the application of science and technology to the development of equipment used in health care.

Many medical and surgical devices which have been made from glass, rubber or metal are now manufactured from PVC. Examples include equipment made for intra-venous feeding, blood transfusion, dialysis and open heart surgery. Such equipment plays a vital role in the continuing advance of medical science.

The blood bag and tubing being used in this operation are made from PVC.

Task 1

Blood bags and tracheal tubes

Working as a group, read and discuss this sheet then identify the following:

- *The purposes for the bags and the tubes.*
- *The conditions under which they are used.*
- *Alternative materials that might be used for blood bags and tracheal tubes.*
- *Possible advantages for using PVC over these other materials.*

Discuss your findings with the class.

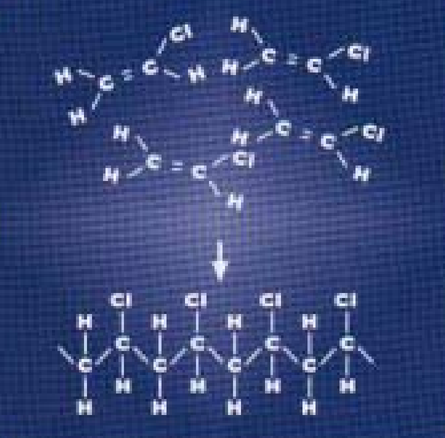
Make a record for future reference.

You will learn more about PVC as you work through later tasks so you may wish to add to your report at a later stage.

What is PVC?

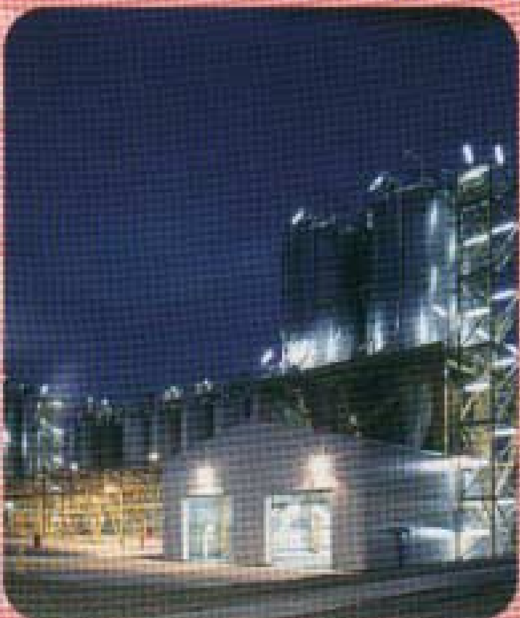
PVC, poly(vinyl chloride) or poly(chloroethene), is made by polymerising vinyl chloride (chloroethene).

molecules of vinyl chloride (monomer)



part of a poly(vinyl chloride) molecule (polymer)

If you need to check your understanding of polymerisation and the classification and naming of polymers consult the Science Ideas and Techniques Sheet, *Polymers and polymerisation*.



A polymerisation plant at night

How is PVC produced?

This flow diagram summarises the main stages in the production of PVC.

Ethene production → **VCM production**

Chlorine production → **VCM production**

VCM production → **PVC production** → **Compound production** → **PVC blends**

Chlorine and ethene are first made from raw materials and then reacted to form vinyl chloride monomer (VCM). This is then polymerised to form PVC.

You will learn more about the reactions involved in these processes when you work through Task 6 but if you want to find out more about them at this stage, then consult other resources such as *The Essential Chemical Industry* published by the Chemical Industry Education Centre, University of York.

PVC is blended with various other materials in the compound plant to make PVC with the desired properties.

Making PVC more useful

Natural and synthetic polymers are seldom used in their pure states. Instead they are blended with a range of other components. These blends are made for a variety of reasons:

- to make processing of the polymer easier,
- to provide the range of properties desired.

The presence of chlorine atoms enables PVC to accept a wider range of concentrations of different components than other polymers.

For example, pure PVC is a rigid material so **plasticisers** are added to give the material some flexibility. Plasticisers are other organic compounds whose molecules are able to separate the PVC chains so that they are more able to move over one another.

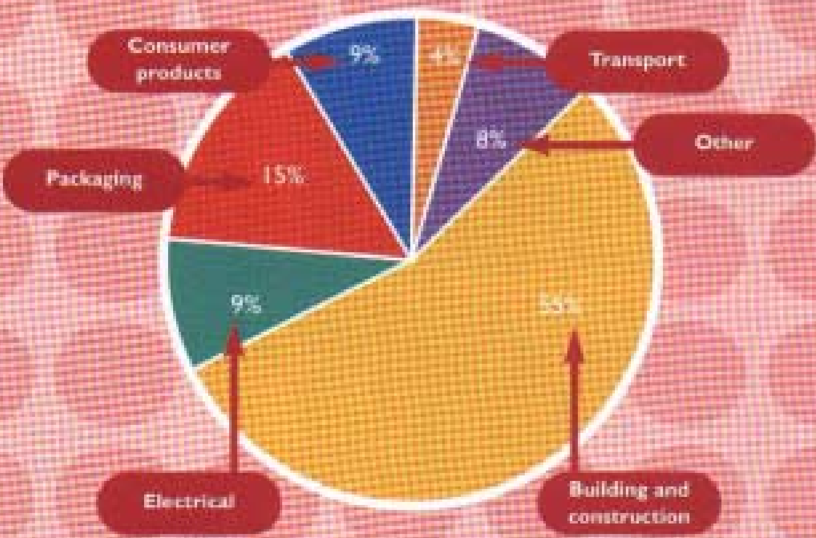
Task Sheet 5 provides guidance for a further study of the modification of properties of PVC

Why use PVC?

Whilst PVC has an extensive range of uses in medical equipment, this accounts for 1% only of the PVC market in Europe.

- Select three of the uses listed and make notes of the properties of PVC which make it particularly suitable for these uses.

The relative proportions of the PVC market



The decision whether or not to use a material to make a particular product should be influenced by an assessment of the complete **life-cycle** of the material when used to make that particular product:

- how the material is produced,
- how the product is made from the material and its advantages in use,
- how it is disposed of.

This sheet concentrates on its use for blood bags and tracheal tubes.

Task Sheet 6 provides an opportunity for you to consider the complete life-cycle of PVC used for blood bags.

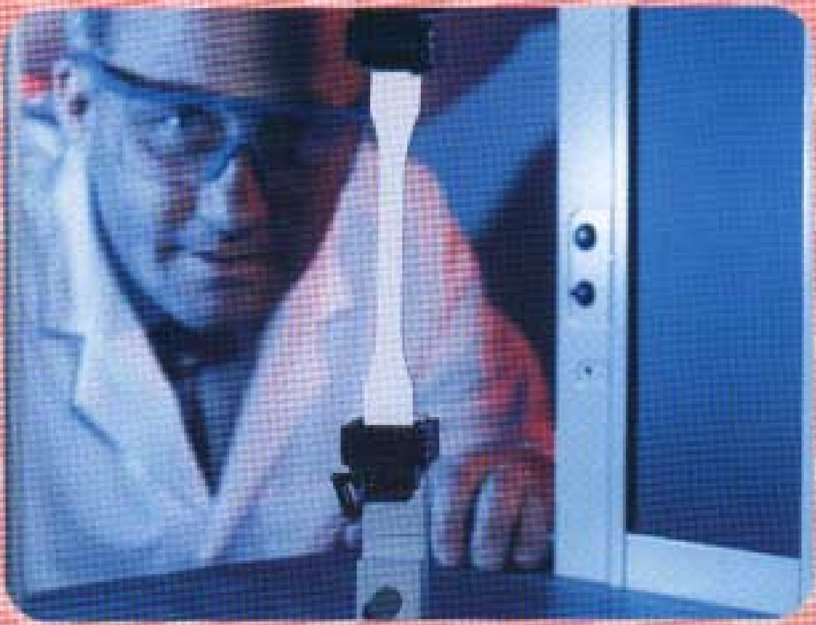
The arguments for using PVC blood bags and tracheal tubes include the following points:

- During the manufacture of the product, solvent-welding and radio-frequency sealing can be used to assemble the different components to make bags with outlet ports and tracheal tubes with inflatable cuffs and one-way valves.
- PVC containers can be steam sterilised as the final step in the manufacturing process, whereas tubes are sterilised in their outer packaging by epoxyethane (ethylene oxide) or gamma radiation.
- There is evidence that the minute amount of plasticiser extracted from PVC by blood has a stabilising effect on the red blood cells so that blood can be stored for 35 rather than 21 days.
- Hospitals must take great care to avoid cross-contamination from one patient to another. Containers and tubing made from PVC are used once only and then disposed of by incineration. Single-trip applications avoid cross-contamination.

Measuring the properties of PVC blends

Polymer technologists need to be able to measure physical properties of PVC such as its hardness, thermal conductivity and how it behaves under tension. This is necessary when new blends are being developed and when checking the quality of products.

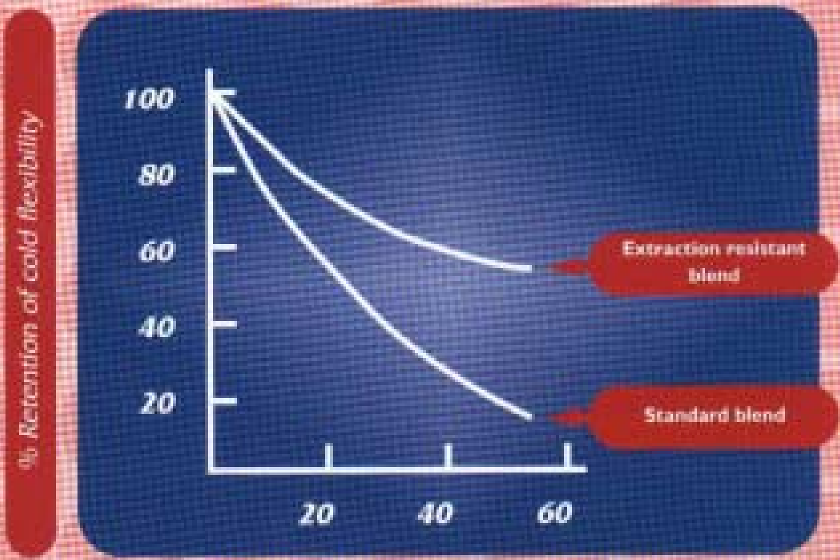
Task Sheets 2, 3 and 4 provide guidance for the measurement of properties of PVC blends.



Investigating the tensile properties of a PVC blend.

For certain medical applications it is particularly important that the PVC has good resistance to body fluids. This property is referred to as extraction resistance which means how well does the plastic resist the extraction of substances from it by body fluids such as blood, the contents of the stomach or gastric juices.

For example, as discussed on the previous page, substances called plasticisers are added to PVC to increase its flexibility. If plasticisers are extracted by fluids the plastic will become less flexible. Therefore monitoring the flexibility provides a way of comparing the extraction resistance of different PVC blends.



Immersion in vegetable oil (days)

The graph shows how immersion in vegetable oil affected the flexibility of standard medical PVC and extraction-resistant PVC.

Another investigation showed that extraction-resistant PVC, when exposed to simulated stomach contents and gastric juices for 56 days, showed no detectable change in flexibility.

Simulated stomach contents and gastric juices

stomach contents

10% soya flour, 20% double cream, 70% custard powder, adjusted to pH1 with HCl and diluted 3 parts mixture to 7 parts water

gastric juices

2 g NaCl and 3 g pepsin dissolved in 7 cm^3 conc. HCl and diluted in 1 dm^3 of water to give a solution with pH 1.2.

Task Sheet 5 provides guidance for an investigation of the extraction of plasticiser from PVC.

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The aim of the
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