

# Plastic recycling from the operating theatres, working towards a circular economy

Tim Vorster  
Consultant Anaesthetist,  
Queen Victoria Hospital,  
East Grinstead

Hannah Burke  
Consultant, Axion  
Consulting, Cheshire

Tom Pierce  
Consultant Anaesthetist,  
Environmental Advisor  
to the President of the  
RCoA, University Hospital  
Southampton

Recycling processes are well established and upwards of 470,000 tonnes of PVC is recycled annually in Europe and nearly 100,000 tonnes in the UK in 2014.

Discard an empty carbonated drinks bottle into the mixed recycling and the handler will refer to the resin identification code, (RIC) embossed in the bottle identifying the bottle as PET (polyethylene terephthalate, Figure 1) to direct the bottle into the appropriate recycling stream. Similarly an empty milk carton will be directed into facilities for HDPE (high density polyethylene, Figure 2). Both PET and HDPE can be recycled back into food-grade plastic containers.

The most widely used plastic in healthcare is polyvinylchloride (PVC, Figure 4), frequently used to form fluid administration sets, tubing and face masks but rather than being recycled this enters the clinical waste stream. Inspired by the Vinyl Council of Australia,<sup>1</sup> a recycling programme called RecoMed has been established in the UK to examine the feasibility of collecting and recycling this high quality PVC in the UK. RecoMed is funded by Vinyl Plus, the voluntary sustainable development programme of the European PVC industry, and is managed by resource efficiency specialists Axion Consulting and the British Plastics Federation.

## Wider use of PVC and PVC recycling

The EU sells 4M tonnes of PVC annually and it is used widely in the construction, fashion and automotive industries. The likelihood is that, within one's home, flooring, guttering, water pipes and cable insulation are all made from PVC. By changing the relative proportions of PVC to plasticiser<sup>2</sup> the functional characteristics of the product can be changed to suit the desired need. Recycling processes are well established, and upwards of 470,000 tonnes of PVC is recycled annually in Europe and nearly 100,000 tonnes in the UK in 2014.

PVC manufacture is a highly energy dependent process requiring 60 megajoules per kg (16kWh) to make a kilogram of new PVC granules. Using recycled PVC reduces the energy requirements by 85%.

## Plastics in anaesthesia and critical care

Only 1% of all PVC manufactured is made into medical devices; however, PVC is used to make 40% of all plastic disposable medical devices.<sup>3</sup> Other commonly used plastics include polypropylene for some ventilator breathing

circuits and thermoplastic elastomers for certain anaesthetic face masks. Some devices are made of different plastics in different parts – certain corrugated breathing circuits for example. Endobronchial and endotracheal tubes, whilst entirely made of PVC, are made of different types of PVC in different parts, and of course they are contaminated once used. Some intravenous fluid bags are composite laminate materials made to improve their chemical resistance and cannot be recycled.

## Ideal characteristics of recyclable medical device PVC

The following characteristics are considered ideal for a PVC device to be recycled:

- High quality PVC item.
- Uniformly made of only PVC.
- Uniform plasticiser content.
- Single type of PVC within the device.
- Ideally clear but coloured PVC is possible.
- Not contaminated with blood or tissue fluids.
- Minimal risk of cross infection.
- Free of metal and other components.

**Figure 1**

The resin identification code found on many carbonated drinks bottles indicating recyclable polyethylene terephthalate. Sometimes the PET is replaced with PETE



**Figure 2**

The resin identification code found on milk containers indicating a recyclable construction using high density polyethylene



**Figure 3**

Once the elastic band and nozzle have been removed the PVC mask is ready to enter the recycling scheme



**Figure 4**

The resin identification code indicating recyclable PVC



- Ideally embossed by the manufacturer to aid PVC identification.

Since they could meet all these criteria, the decision was to pilot the feasibility of PVC recycling at Frimley Park NHS Hospital, Surrey followed by Queen Victoria Hospital, East Grinstead. The pilot concentrates on the ‘Hudson’ style of face mask with its associated clear oxygen tubing and patient’s cushioned anaesthetic facemask.

## Regulations and safety

The Environment Agency is responsible for regulating waste management in order to protect hospital staff, the public and waste disposal workers from exposure to hazardous and infectious waste. The grey area is ‘clean’ waste that has touched an elective non-infectious patient. The Environment Agency supported this pilot and classified the collection, treatment and recycling process as a low-risk waste activity provided it was carried out by RecoMed’s specialist recycler. Within both hospitals, infection control teams undertook independent risk reviews, concluding that the PVC oxygen masks and tubing were a non-hazardous waste with a low infection risk. Importantly these assurances provided the staff with the freedom from personal liability.

## Staff engagement

When developing the PVC recycling scheme, RecoMed worked closely with clinical teams, hotel and environmental services and infection control. Both hospitals had embraced ‘total waste solutions’ already, involving the segregation of waste into clinical, mixed-recycling and domestic waste streams. The RecoMed team provided additional training sessions and communication material so that it was clear to the staff what could be recycled and what should not be put in the RecoMed collection bins.

## Collection and recycling

Recovery staff used their discretion, and discarded any items that were obviously soiled with bodily fluids or from a potentially infectious patient, into a clinical waste bin. On discharge from the recovery unit, provided patients no longer required ongoing oxygen therapy, the elastic straps and polypropylene nozzle were manually removed from the ‘Hudson’ mask and the mask and its tubing were discarded into a clear labelled recycling bin along with the anaesthetic facemask, which accompanied the patient to recovery (Figure 3). Once introduced, compliance with the process reached

nearly 100% and cross contamination of the recycling bins with other waste was zero. In its present form, the outlay for the hospitals is in staff time only.

Hotel and environmental services worked together to ensure that the daily waste collection schedule included the RecoMed bags which were then taken to a central waste hold before collection by the RecoMed team and subsequent delivery of the PVC from the hospital to the recycler.

## The end product of recycled medical grade PVC

Whilst the PVC that goes to make ones windows and facias can be recycled into new windows and facias up to eight times, recycling medical devices, including face masks, into new face masks is not permitted under the regulations. EU medical directive 93/42/EEC<sup>4</sup> ensures that devices will not harm or pose a health risk and EN/ISO 10993<sup>5</sup> covers biological testing. Since the recycled product has an uncertain pedigree, a used face mask cannot be recycled into another face mask. The specialist recycler shreds the PVC and produces 100% recycled horticultural products such as tree ties.<sup>6</sup> The temperature of the process ensures the denaturing of all biological residues. There remains the possibility that, in time, recycled PVC could be used to manufacture products that serve as collection devices, such as urine collection bags, nasogastric collection bags and dialysis effluent collection bags.

## Financial and carbon savings

Yellow bagged clinical waste is incinerated at a cost of about £630 a tonne and orange bagged clinical waste is steam or microwaved treated at a cost of about £200–300 per tonne. The financial saving of recycling depends on the local waste stream management and any additional costs incurred in the recycling process. With the process in its infancy, the carbon saving is complex and has yet to be calculated.

## The next steps

Once the financial and carbon savings are defined the case can be made for wider roll-out of recycling PVC and possibly other plastics. Working with The Environment Agency and other regulators to ensure safety is vital. It would aid identification if recyclable PVC could be embossed with the RIC (Figure 4). In the longer term, other plastic devices may be worth recycling, especially if made of a single type of plastic.

## The linear and circular economies

The linear 'take, make and dispose' model relies on large quantities of non-sustainable resources, in the case of PVC, petrochemicals, energy and salt. The circular economy,<sup>7</sup> involves the continual flow of technical and biological materials through the value circle. This pilot has demonstrated the practical feasibility of recycling, high-quality, medical-grade PVC albeit into lower-value products. Multinational organisations are working towards circular economies in car and food manufacture, then why not the healthcare industry too? From face mask to face mask.

### References

- 1 PVC recovery in hospitals (<http://bit.ly/1HQtpcB>) (accessed 29 April 2015).
- 2 Walton AM, Pierce JMT. Polyvinylchloride phthalates and packaging. *RCoA Bulletin* 2014;**86**:29–31.
- 3 PVC Med Alliance ([www.pvcmed.org](http://www.pvcmed.org)) (accessed 29 April 2015).
- 4 Medical Devices. Directive 93/42/EEC. European Commission (<http://bit.ly/1Gv8DVk>) (accessed 29 April 2015).
- 5 Biological evaluation of medical devices – Part 1: Evaluation and testing within a risk management process (ISO 10993-1:2009) (<http://bit.ly/1Gv8RM9>) (accessed 29 April 2015)
- 6 Rainbow buckle tree ties. Green-tech (<http://bit.ly/1Gv9bKX>) (accessed 29 April 2015).
- 7 The Ellen MacArthur Foundation ([www.ellenmacarthurfoundation.org](http://www.ellenmacarthurfoundation.org)) (accessed 29 April 2015).

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Registered Office: Department of Anaesthesia, University of Liverpool, Duncan Building, Daulby Street, Liverpool L69 3GA.