The Challenges of Recycling Single-Use Vapes

A Waste Experts Report

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Executive Summary

With the increasing popularity of single-use vapes, more than 1.3 million are discarded every week in the UK, Waste Experts were approached to carry out recyclability testing of two single-use vapes.

The purpose of this testing was to evaluate the materials recyclability and recoverability of a widely-available, single-use plastic and aluminium vape (Product A) and a new cardboard-based entry (Product B) on the UK market, to gain insights into the recyclability of the products in line with ISO 14021:2016.

Even though both products were not specifically designed for disassembly at the end of their useful life, the levels of recyclability are high. No specialist tools were required, however due to the hazardous nature of the components and in particularly the flammability of the lithium battery it is not recommended that these are disassembled by an end user and should be treated by a specialist recycling facility.

Cardboard components were all presented in a 'new' condition which will facilitate a high recycling rate; however, consideration should be given to treatment of used units where condition may deteriorate due to length of use and/or storage pending treatment.

Where more than one product is tested to make a comparative claim, this should be expressed in percentage terms and therefore the comparison made as an absolute difference.

Product A contains 5.3% more recyclable components by weight (80.1% of the material was recyclable, compared with 74.8% for Product B). Looking at 'diverted from landfill' (so recyclability plus recoverability), Product B performed better (99.3% compared with 97.6% for Product A). In terms of disposal to landfill, Product B performed better with 0.7% sent to landfill compared with 1.15% for Product A.

The test's concluded that both products tested, when collected and sent to an Approved Authorised Treatment Facility, are able to meet the UK Recycling and Recovery Targets under the WEEE directive. So whilst single-use vapes have a short life span and are not environmentally the best option, when collected and treated through authorised routes, the materials can be recycled and recovered correctly.

The Challenges of Recycling Single-Use Vapes

1. Introduction

Insatiable demand and a flourishing electronics industry is creating copious amounts of e-waste. E-waste is the world's fastest growing waste stream and has become a global concern owing to the potential for environmental damage and the loss of rare earth materials. Different types of products create different process issues, and currently 'vape waste' – discarded vape products – is making headlines in the UK. Disposable or single-use vapes, or electronic cigarettes are now the most popular e-cigarette in the UK today. The result is that these have become potentially problematic in terms of environmental impact and waste management because most consumers dispose of them in regular household waste ***[REF 1]***, even though it is UK law that they are required to be recycled under the WEEE directive. This shows a lack of availability and knowledge of recycling and collection systems for consumers despite the waste industry being able to collect and process them. In this study, we therefore sought to determine the recyclability of an existing, widely available, single-use e-cigarette brand and a new-to-market, cardboard-based product.

1.1 Waste Electrical and Electronic Equipment (WEEE) regulations

Vape products are classified as waste electrical and electronic equipment (WEEE) and are covered by WEEE regulations (***[REF 3]*** https://www.legislation.gov.uk/uksi/2013/3113/pdfs/uksi_20133113_en.pdf). These regulations aim to limit environmental impact by reducing the amount of electronic waste going to landfill and the correct management of hazardous components. These regulations promote the separate collection, treatment, and recycling of electrical and electronic goods. WEEE has 14 categories, based on the type of product and its intended use, which determines the requirements for recycling.

Vapes fall under category 7 'Toys, leisure and sports equipment'. Under the WEEE directive, vapes must be recycled separately from other household waste and taken to a recycling facility that is authorised to treat them. Producers are responsible for funding the recycling of products in a compliant manner, and Consumers need better education on how and where they can take their vapes, to be able to access compliant recycling routes. Vapes should be taken either to a household recycling centre or back to where they were purchased. But recent reports suggest that consumers are largely unaware that vapes can or should be recycled.

In addition, if damaged when thrown away, lithium batteries can cause fires in landfill or at waste treatment facilities and need to be handled with care. This contrasts with many other recyclable waste streams (that can be managed by mechanical processes), which adds to the cost of managing expired vape waste.

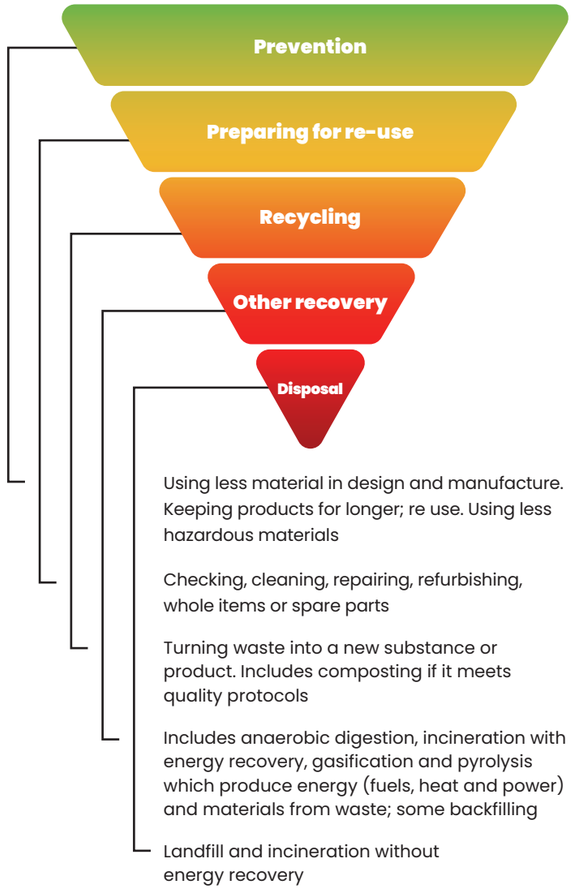
Vape manufacturers also have obligations including a requirement to report on how many products they put on the market and for funding programmes to ensure that their products are collected for recycling or disposal in an environmentally responsible manner.

1.2 The waste hierarchy

The UK government uses a waste hierarchy ***(Figure 1)*** which is applied to all waste according to what is the best outcome for the environment. The most preferred option is 'prevention' (using less material in design and manufacture, as well as stopping products from becoming waste by making the product last longer) and the least preferred is disposal (landfill and incineration without recovery); in between are re-use (finding ways to reuse products, with minor refurbishments/repairs), recycling (converting waste materials into new products), and recovery (recovering energy or other resources from waste materials via incineration, gasification, or anaerobic digestion). Since 2011, all entities that produce and handle waste have been legally required to follow the waste hierarchy (Directive 2008/98/EC). ***[REF 4]***

In the context of WEEE regulations, approved authorised treatment facilities (AATFs) issue evidence notes for household obligated WEEE (via a secure website), and must be able to demonstrate that they are achieving the recovery and recycling targets (also called 'diverted from landfill'). For vapes (category 7), these targets are 75% recovery and 55% recycling ***[REF 5]***. Detailed records must be kept (e.g. site input and output for WEEE or WEEE-derived materials that are received and sent to third party sites for recovery and recycling).

Figure 1. The waste hierarchy.



1.3 Waste electrical and electronic equipment (WEEE): appropriate measures for permitted facilities

In the UK, AATFs follow Guidance on Waste electrical and electronic equipment (WEEE): appropriate measures for permitted facilities ***[REF 7]***, which is a framework used to ensure that hazardous materials are treated correctly. Appropriate Measures considers the environmental impact of different treatment and recovery methods. For WEEE, recyclability is assessed based on how easily components can be separated and processed for reuse.

1.4 How Waste Experts are helping vape manufacturers meet their obligations.

For expired vapes, Waste Experts use testing methods in line with best practice as advised by the International Standards Organisation (ISO). The ISO standard ISO 14021:2016 ***[REF 5]*** provides guidelines for self-declared environmental claims (including statements, symbols and graphics about products) made by businesses about their products. Further, this standard defines key terms and provides general requirements for making accurate and verifiable claims. In addition, it aims to ensure that environmental claims are relatively comparable and easy to understand for consumers. Within the recyclability test, consideration must also be given to the packaging and any material generated throughout the manufacturing process that is diverted from landfill excluding any materials reclaimed within the same process that generated it. Consideration is also given to the ease of recycling, the time taken per unit, the packaging by type and the components of the items and the current recycling and recovery options available for the material.

The overall objective for manufacturers is to provide a declaration of recyclability that uses accurate information to encourage the demand for and supply of products that will reduce their impact on the environment. Such claims cannot be vague or non-specific. Although we can provide as much carbon data as are available at the time of testing, the concepts involved in sustainability are highly complex and still evolving, which means there are no definitive methods of measuring sustainability at present. We use carbon metrics supplied by the manufacturer as an 'embedded' carbon measure and savings of recycling versus a loss of the embedded carbon where a product is sent to landfill will be provided. And of course, we advise our clients that products should be reassessed and updated as necessary to reflect changes in legislation, technology, competitive products, or other circumstances that could alter the accuracy of environmental claims.

1.4.1 Recycling expired vapes

Most of the vapes sold in the UK are manufactured overseas, and may be produced outside of ROHS (Restriction of Hazardous Substances Directive 2002/95/EC) regulations ***[REF 6]***; therefore it is not possible to rule out the presence of persistent organic pollutants (POPs) in any of the plastic components or printed circuit board that might be present in a vape device. Typically, such POPs are in the form of brominated flame retardants (BFRs). So, to comply with guidance from the UK Environment Agency, all plastics found in vapes must be treated as if they contain POPs, and sent for density separation to maximise the recycling of vape plastics.

Over time, we expect this to change – thus far, there has not been a sufficiently high volume of vape material accumulated to allow for individual measurement to be taken, which would allow us to obtain waste-specific segregation results.

In addition to the low volumes of vapes being collected and treated for recycling, the composition of vapes makes mechanical processing challenging as we have not seen enough vapes, there is a requirement to make sure that any mechanised process would need to be approved by the Environment Agency. We have therefore developed a compliant treatment process for this waste stream ***(Figure 2)***. We are already recycling and recovering tonnes of material from the vapes that we process daily. From the typical recycling percentages, we observed during method development ***(Table 1)***, it is clear that these products are highly recyclable when sent to and managed by an Approved Authorised Treatment Facility (ATF) such as our recycling facility in Huddersfield, Yorkshire.

For vapes, we report recycling and recovery rates based on material as a percentage of the overall weight of the sample. All materials except for the battery have recycling and/or recovery options within the UK. For example, laminated cardboard can be used in low-grade paper products such as drinks holders, whereas standard cardboard will be used as future high-quality cardboard packaging. Options for recycling plastic wrapping are limited at present, with much of this material going into 'energy from waste' applications.

1.5 Objectives of the testing

In this study, we evaluated materials recyclability and recoverability between a widely available, single-use vape product (Product A) and a new-to-market cardboard-based vape (Product B) in order to assess the environmental credentials of the two products.

Expired vape		Recycling rates			CO2 saving (per tonne)
Material	%	% Recycled	% Recovered	% Disposed	
Aluminium	42.86%	42.86%	0.00%	0.00%	40.71%
Plastic	14.29%	7.40%	6.26%	6.97%	4.29%
Lithium battery	35.71%	35.71%	0.00%	0.00%	18.50%
E-liquid/swab	7.14%	0.00%	7.14%	0.00%	–4.07%
Total	**100.00%**	**85.97%**	**13.40%**	**6.97%**	**59.43%**

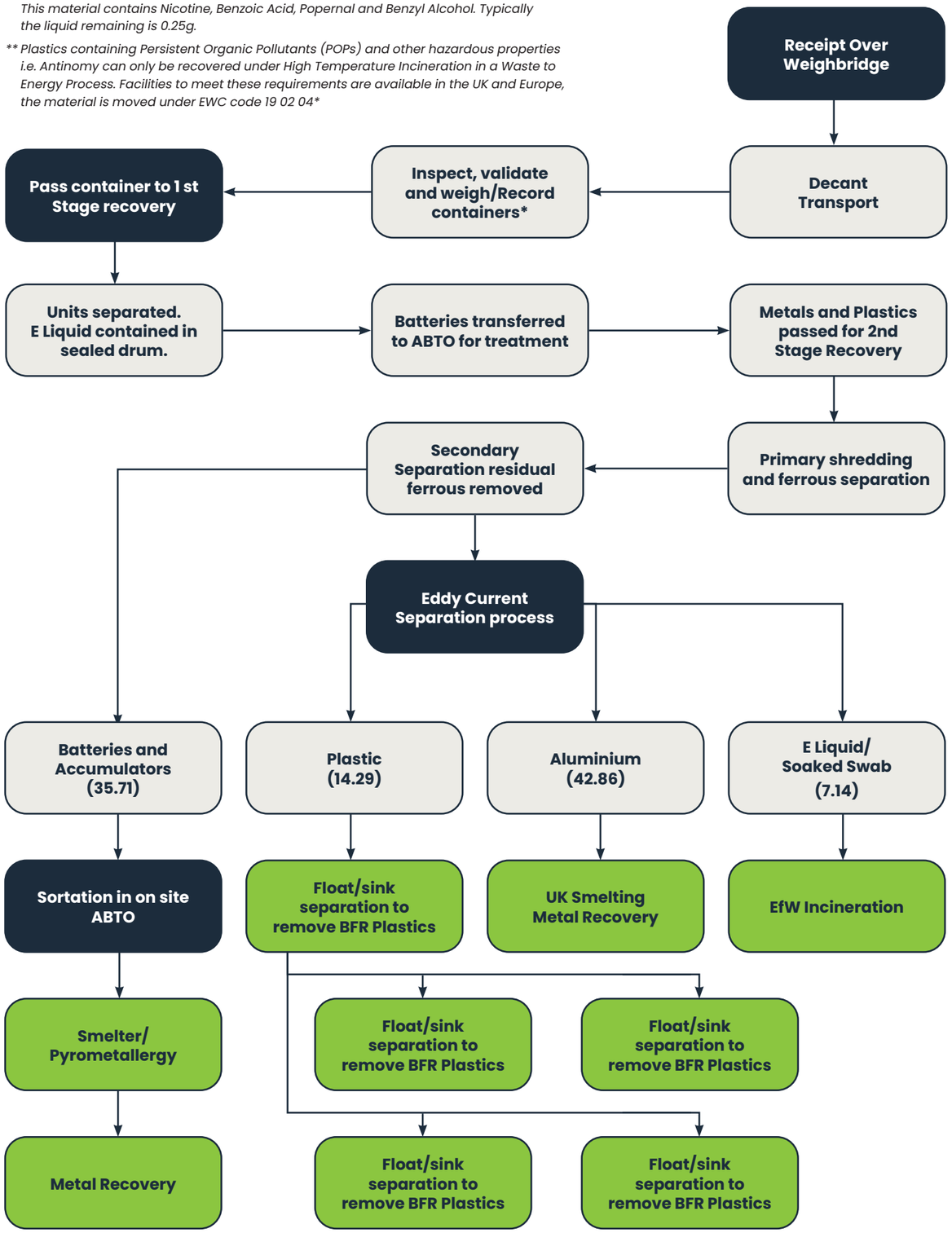
Table 1. Typical recycling rates of materials in expired single-use vapes, based on our research at Waste Experts.

Figure 2. Schematic outlining Waste Experts methodology for managing expired vapes.

Expired E-Cigarette Processing

* *E Liquid is either contained in a reservoir or is in the form of a liquid soaked swab. This material contains Nicotine, Benzoic Acid, Popernal and Benzyl Alcohol. Typically the liquid remaining is 0.25g.*

** *Plastics containing Persistent Organic Pollutants (POPs) and other hazardous properties i.e. Antinomy can only be recovered under High Temperature Incineration in a Waste to Energy Process. Facilities to meet these requirements are available in the UK and Europe, the material is moved under EWC code 19 02 04**



Materials and Methods

2.1 Methods

The present study was conducted in the UK, with material analysed and data collected in April 2023. The process used for dismantling expired vapes was followed ***(Figure 2)***. Waste disposal of the materials used to package the vapes was included in the assessment.

2.2 Products analysed

Two single-use vape products were provided as new and were analysed in this study ***(Figure 3)***. Each product was delivered in a large box, containing 250 units packaged within smaller display boxes protected with polystyrene chips. Product A was a compact, puff-actuated, single-use plastic vape product. This product is available in a wide variety of flavours and nicotine strengths and is the UK's leading single-use brand by a significant margin.

Product B was a compact, cardboard-based, puff-actuated, single-use vape product.

Figure 3. Study Product A and Study Product B.

PRODUCT A

PRODUCT B – ANDS SLIX

2.3 COSHH assessment

In the UK, COSHH (Control of Substances Hazardous to Health) regulations require that employers control substances that are potentially hazardous to health. Both test products contain small amounts of nicotine in the e-liquid reservoirs. At high concentrations, nicotine is acutely toxic, corrosive, and hazardous to aquatic environment. There is also a further fire hazard due to the lithium battery used within both types of vapes. We therefore conducted a COSHH (Control of Substances Hazardous to Health) assessment. As explained above, all plastic components in vapes must be treated as if they contain POPs and appropriate precautions taken, so the plastic components were subjected to density separation to remove heavy brominated fractions.

2.4 Testing conditions

All testing was carried out in a controlled environment with staff wearing appropriate personal protective equipment (PPE). Exposure to the hazards was well below the long-term exposure level (LTEL, the time weighted average concentration of substance over an 8-hour period thought not to be injurious to health or 8hrTWA).

Results

3.1 Processing and analysis of Product A

We dismantled and analysed the waste disposal of 250 units of Product A in a variety of nicotine strengths and flavours (shop keeping units or SKUs; ***Figure 4***). The gross weight of the sample was 12 kg. In brief, each display box was wrapped in plastic shrink wrap, which was removed. Each individual unit within the outer display cases was contained within an inner laminated cardboard case, which in turn contained the single-use vape inside a sealed plastic wrapper and an instruction leaflet, all of which were removed. Owing to its composite nature, the plastic wrapper was sent with other material to be recovered within energy from waste applications.

Each vape was then dismantled individually following the process outlined in ***Figure 2***. First, the plastic ends were removed, followed by the battery, the wires of which were sniped from the nicotine wad. An aluminium case was removed from the plastic mouthpiece and ends for separation and recycling. Across the packaging and the vape, 11 components were segregated ***(Figure 5)***: nicotine cartridge, e-liquid, aluminium, plastic, lithium batteries, cardboard, laminated card, foam packaging, plastic packaging, plastic shrink wrap and paper leaflets ***(Table 2)***. In total, it took 210 minutes to dismantle all 250 units.

Figure 4. Step by step disassembly of Product A.

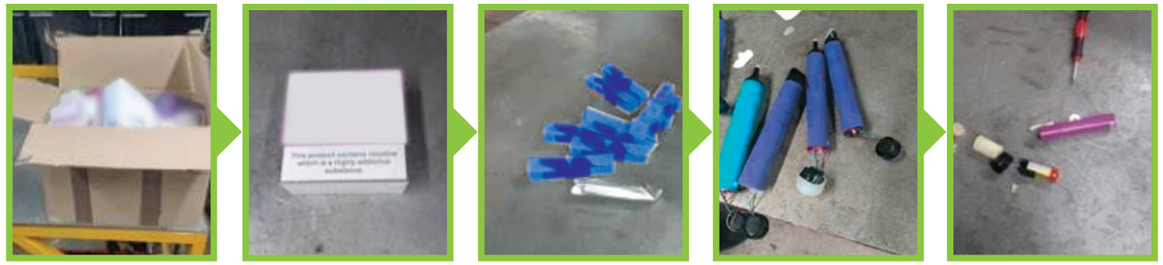
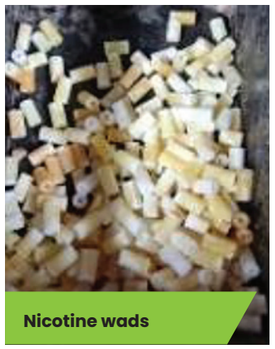
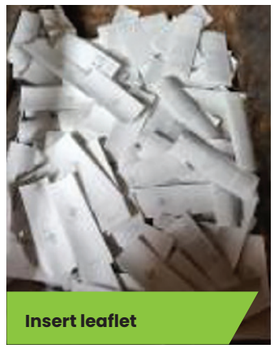
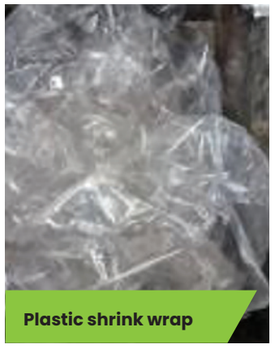


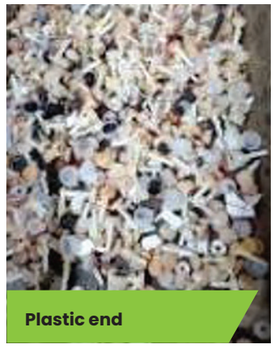
Figure 5. Output materials from disassembly of Product A.

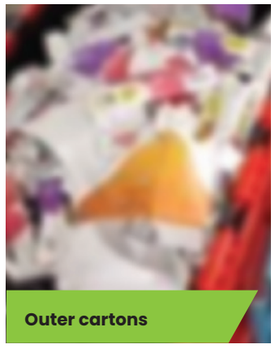
We analysed the waste options for each of the 11 components of Product A ***(Figure 5; Table 2)****.*
In total, 97.61% of the material was recyclable or recoverable.

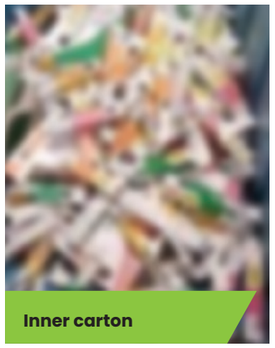












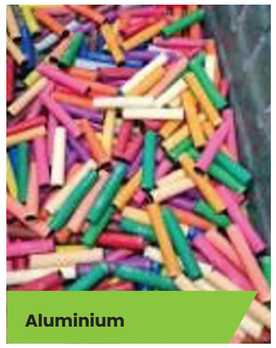


Table 2. Analysis of waste components of Product A.

Waste component	Weight (kg)	Percentage of component	Fraction recycled	Fraction recovered	Fraction disposed	Process Loss
Nicotine cartridge	0.75	6.25%		6.25%		
E-liquid	0.15	1.25%				1.25%
Aluminium	2.6	21.67%	21.67%			
Plastic	1.85	15.42%	6.75%	7.52%	1.14%	
Lithium batteries	2.64	22.00%	22.00%			
Cardboard	0.46	3.83%	3.83%			
Laminated card	2	16.67%	16.67%			
Foam packaging	0.9	7.50%	7.50%			
Plastic packaging	0.3	2.50%		2.50%		
Plastic shrink wrap	0.15	1.25%		1.25%		
Paper leaflets	0.2	1.67%	1.67%			
Total	**12**	**100.00%**	**80.09%**	**17.52%**	**1.14%**	**1.25%**

** Process loss is liquid that transferred from cartridges to gloves/workbench and was not recoverable.*

In terms of recyclability, 80.09% of the material was recyclable, in other words, suitable for reprocessing to be used again in manufacture. This corresponded to 100% of the aluminium, cardboard, laminated card, and the lithium batteries, and 43.8% of the plastic in the main body of the vape. Although the display- casing card is 100% recyclable, the quality of laminated card means that after recycling it is only suitable for 'secondary uses' (i.e., low quality paper items such as coffee cup holders). In contrast, standard non-laminated cardboard is more likely to be returned to high-quality cardboard packaging.

In terms of recoverability, 17.52% of material was recovered in an energy from waste application (high-temperature incineration). For the plastic in the main body of the vape, 48.8% was recoverable. For the plastic packaging and plastic shrink wrap, 100% both was recovered in high-temperature incineration.

In terms of disposal, 1.14% of the material was disposed of, corresponding to the remainder of plastic from the main body of the vape (7.39% of this plastic element). This material was lost during the high-temperature incineration and is known as 'incinerator bottom ash' (IBA). The final 1.25% of the material represents e-liquid that was transferred from nicotine cartridges to staff gloves or workbenches and was not recoverable. This material is termed 'process loss'.

3.2 Processing and analysis of Product B

Using the same procedure as above, we dismantled and analysed the waste disposal of 250 units of Product B, in a variety of SKUs ***(Figure 6)***. The gross weight of the sample was 9 kg. There was less packaging and no information leaflet in Product B; in addition, the display boxes and individual vape boxes used for Product B were made from non-laminated card, which can be recycled into high-grade cardboard products, the cardboard components were all presented in a 'new' condition which will facilitate a high recycling rate; however, consideration should be given to treatment of used units where condition may deteriorate due to length of use and/or storage pending treatment.

The units of Product B were much easier to dismantle. Across the packaging and the vape, seven component parts were segregated ***(Figure 7)***: nicotine cartridge, plastic, lithium batteries, cardboard, foam packaging, plastic, shrink wrap and rubber ***(Table 2)***. In total, it took 90 minutes to dismantle the 250 units.

We analysed the waste options for each of the seven components of Product B ***(Figure 7, Table 3)***. In total, 99.29% of the material was recyclable or recoverable.

In terms of recyclability, 74.78% of material was recyclable, in other words, suitable for reprocessing to be used again in manufacture. This corresponded to 100% of the cardboard packaging, which, as mentioned above, can be re-used in high-quality cardboard packaging materials. There was no laminated card used in any of the packaging. In addition, 100% of the lithium battery and foam packaging, and 43.4% of the plastic in the main body of the vape, were recyclable.

In terms of recoverability, 24.51% of material was recovered in an energy from waste application (high-temperature incineration). This corresponded to 48.8% of the plastic in the main body of the vape, along with 100% of the nicotine cartridge and 100% of the plastic shrink wrap.

In terms of disposal, only 0.72% of the material was disposed of, corresponding to the remainder of plastic from the main body of the vape (7.4% of this plastic element). This is material (IBA) was lost during the high-temperature incineration process.

There was no process loss because the e-liquid element was contained and dry, and so did not transfer to any of the containment or work areas.

Figure 6. Step by step disassembly of Product B.

Figure 7. Output materials from disassembly of Product B.

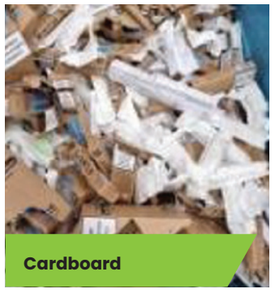


Table 3. Analysis of waste components of Product B.

Waste component	Weight (kg)	Percentage of component	Fraction recycled	Fraction recovered	Fraction disposed	Process Loss
Nicotine cartridge	1.75	18.82%		18.82%		
Plastic	0.9	9.68%	4.24%	4.72%	0.72%	
Lithium batteries	2.07	22.26%	22.26%			
Cardboard	4.35	46.77%	46.77%			
Foam packaging	0.09	0.97%	0.97%			
Plastic shrink wrap	0.09	0.97%		0.97%		
Rubber	0.05	0.54%	0.54%			
Total	**9.3**	**100.00%**	**74.78%**	**24.51%**	**0.72%**	**0%**

Discussion

In the UK, single-use vapes are now the fastest growing segment of the vape product category with considerable consequences for the environment. Due to a lack of consumer awareness and understanding, these products mainly are discarded in regular household waste, presenting a growing environmental challenge. Although some environmental campaigners are calling for a ban on single-use vapes (e.g. in Scotland ***[REF 8]***), most news reports fail to focus on the fact that consumers don't try to recycle these products because they do not know they should or have easy access to a recycling option, this is, in fact, the key issue when it comes to environmental concerns around most waste streams and is not unique to vapes.

There are challenges to the effective recycling of vapes. (1) The devices are made up of multiple components and mixed materials. (2) Due to the hazardous materials found in vapes, they need to be dismantled by hand as there is no current method to safely mechanically treat all types of vapes, this includes the e-liquid container could contaminate the processed materials and there is a high fire risk when mechanically treating lithium batteries – this leads to an expensive and also rate-limiting step because suitably qualified personnel are needed. Nevertheless, single-use vapes are actually highly recyclable (74%–80%) and recoverable (17.5–24.5%) as demonstrated in this report and should be sent for recovery by law under the WEEE directive, although more should be done by manufacturers to include prevention and reuse under the waste hierarchy.

It is worth noting that the cardboard components were all presented in an 'as new' condition, which will facilitate a high recycling rate. However, consideration should be given to treatment of used units where condition may have deteriorated due to length of use and/or storage pending treatment. This underscores some of the potential challenges in recycling vapes, and suggests that extra attention or specialised treatment might be required for used devices that have degraded over time to ensure appropriate waste management.

Conclusion

It is clear from the analysis that single use vapes can be recycled, and can achieve the recycling and recovery targets to meet the WEEE directive. The sector is very resourceful when it comes to new ways of working when it comes to the treatment of difficult and challenging waste streams. The more we can do as a sector to educate all stakeholders the better.

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Declaration

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