De-Wipe
Investigation report

Assessing De-Wipes ability to remove dioxins (PCDD/Fs) and polycyclic aromatic hydrocarbons (PAHs) from different surfaces
Report Number: R/DW001/F

Manchester
Metropolitan
University

De-Wipe

Contents

Executive Summary

Aim

The primary aim of this investigation was to undertake controlled laboratory testing to assess the effectiveness of a De-wipe at removing contamination likely to be experienced from fire debris. Two classified pollutants; polycyclic aromatic hydrocarbons (8 most toxic tested) and hydrochloride dioxins (17 most toxic tested)

Approach

We undertook an investigation to assess the performance of the De-Wipe against other technologies in a controlled laboratory setting. Two classes of pollutants were investigated, dioxins (PCDD/Fs and polycyclic aromatic hydrocarbons (PAHs). Both are carcinogenic compounds that have been previously identified in fire debris and so pose a potential health risk to the UK Fire and Rescue Services. Wipe tests were performed on three different surfaces (skin, polycarbonate and rubber), solvent extracted and analysed by gas chromatography with tandem mass spectrometry.

Results and Conclusions

The results of this investigation concluded that the De-Wipe is effective at removing dioxins and PAHs from skin.

(1) Introduction

Emissions of polycyclic aromatic hydrocarbons (PAHs) and polychlorinated dibenzo-*p*-dioxins and dibenzofurans (PCDD/Fs) are (by-)products of combustive and industrial processes (Bumb et al., 1980; Rappe, 1996; Hsu et al., 2011).

A variety of materials that emit PCDD/Fs and PAHs during (accidental) fires, including wood, polyvinylchloride (PVC) and chlorinated compounds (Vikelsøe and Johansen, 2000; Blomqvist et al., 2007; Hsu et al., 2011). Flame-retardants are commonly used in commercial and residential materials, i.e. “altering” the material to become harder to burn, due to fire safety regulations to protect people and premises from fire (UK: *The Regulatory Reform (Fire Safety) Order 2005*; (UK Government, 2005; Betts, 2008; Morgan and Wilkie, 2010). Firefighters are exposed to various toxic chemicals, both during and while cleaning up after fires, including PAHs, polychlorinated biphenyls (PCBs), polychlorinated dibenzo-p-dioxins and dibenzofurans (PCDD/Fs), (heavy) metals and various combustion by-products (O’Keefe et al., 1985; Brandt-Rauf et al., 1988; Bolstad-Johnson et al., 2000; Schecter et al., 2002; Edelman et al., 2003; Hsu et al., 2011; Shaw et al., 2013). Extent and nature of exposure are highly variable and are dependent on number of fires, types of firefighting performed and personal habits (Shaw et al., 2013). However, exposure to compounds, such as PAHs and PCDD/Fs is related to severe human health impacts, e.g. cytotoxicity and mutagenicity and carcinogenicity of PCDD/Fs and PAHs (IARC, 2002, 2010; Shaw et al., 2013; Oliveira et al., 2017). As first responders to fire incidents, firefighters are often systematically exposed to significant amounts of these thermal by-products, causing increased rates of disease and long-term health problems amongst the firefighting community, for instance cancers, e.g. bladder, kidney, lung and leukaemia (Stec et al., 2018).

Personal protective equipment (PPE), protecting the firefighter against safety risks and hazards, e.g. the lungs from breathing contaminated air and the body from extreme heat (HSE, 2019). However, a large number of potential harmful compounds have been measured on firefighter PPE, including PAHs and flame-retardants (Stull et al., 2009; Baxter et al., 2010, 2014, Alexander and Baxter, 2014, 2016; Easter et al., 2016; Fent et al., 2017). Occupational exposure to these toxins of firefighters has been associated with excessive morbidity and mortality (Soteriades et al., 2011; Gaughan, Piacitelli, et al., 2014; Gaughan, Siegel, et al., 2014; Oliveira et al., 2017).

The procedure for cleaning the fire crew’s PPE, also known as ‘turnout gear’, varies by county level and station (Baxter et al., 2014). Fire departments are encouraged to regularly clean and repair firefighter equipment, either by professional cleaning services or centralised locations (Walker and Stull, 2006). However, wear and cleaning processes can damage materials over time and cleaning might not be effective enough to remove contaminants, resulting in reduced protection from potential harmful toxins (Mueller, 1991; Walker and Stull, 2006; Stec et al., 2018). Additionally, chemicals can penetrate through the protective equipment and permeate into fibres and coatings, remaining for long periods of time (Walker and Stull, 2006). Due to permeation and penetration of contaminants, as well as cross-transfer of contaminants from gear to skin, skin exposure is one of the major exposure route for firefighters (Fent et al., 2017). Less volatile substances could also be transferred to vehicles and living spaces used by the fire department crew (Brown et al., 2014; Shen et al., 2015; Fent et al., 2017).

It is therefore necessary to identify potential additional methods to efficiently clean firefighters and their PPE from harmful contaminants. In this study, different surfaces, including skin , polycarbonates (substitute for helmet/mask) and rubber (substitute for self-contained breathing apparatus [SCBA] equipment) were tested, using the available technologies presented in Table 1..

Table 1: Materials and cleaning agents tested within this study. Surfaces were wiped two times (x2) with specific product

		Products				
		De-Wipe	OtherWipe1	OtherWipe2	OtherWipe3	OtherWipe4
Surfaces	Plastic	x2	x2	x2	x2	x2
	Skin	x2	x2	x2	x2	x2
	Rubber	x2	x2	x2	x2	x2

(2) Method

A schematic overview of the surface wiping procedure and extraction method is illustrated in Figure 1.

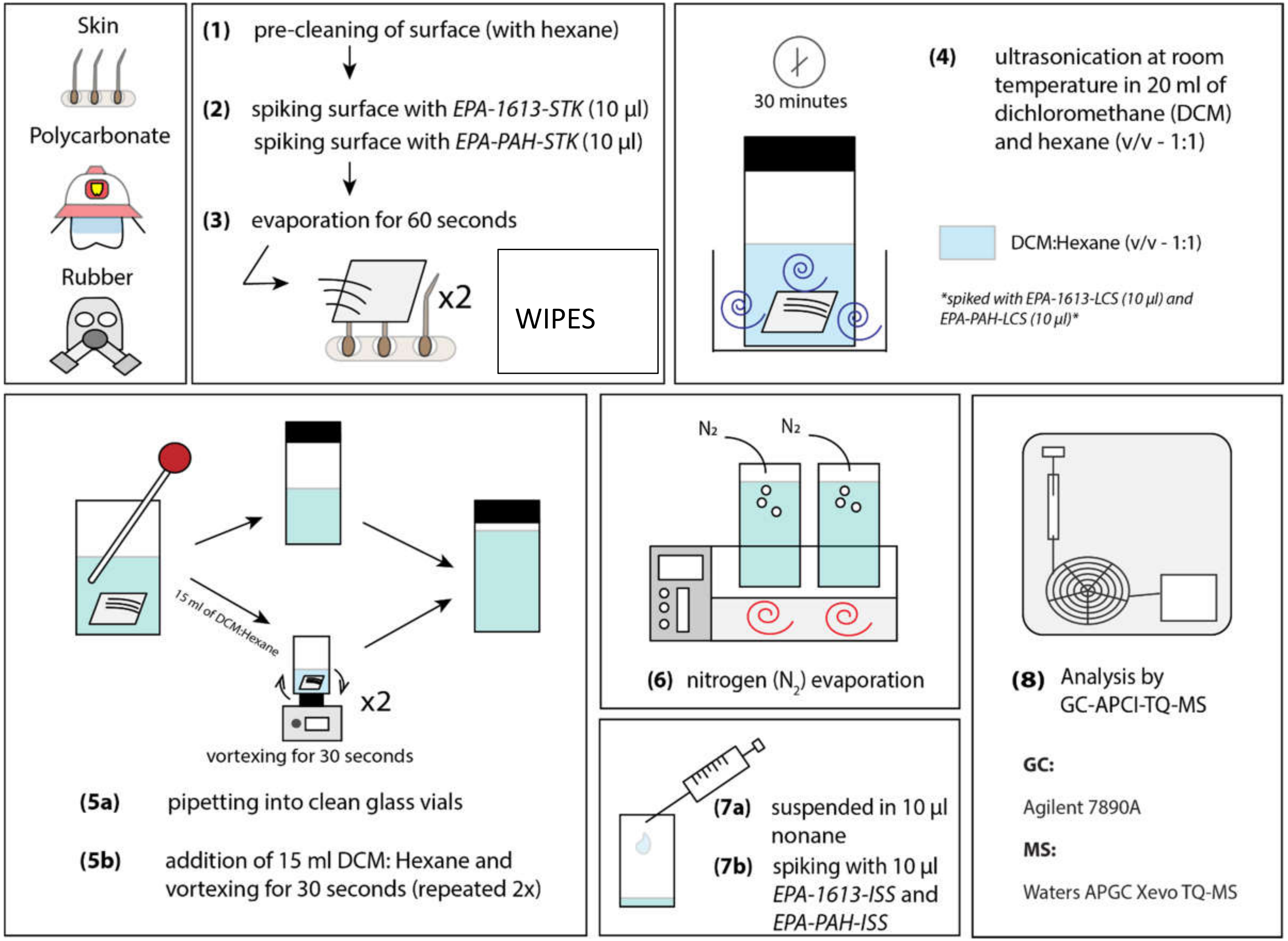


Figure 1: Schematic overview of extraction method for dioxins, furans and PAHs from tested surfaces (skin, polycarbonate and rubber), wiped with different available products.

(3) Results

Wipe extracts were analysed for 17 2378- substituted PCDD/Fs, and 8 PAHs containing 4- or more rings (i.e. 4-, 5- and 6-ring PAHs). Seventeen of the 210 PCDD/Fs were targetted as these were the 2378- chlorine subsituted congeners that pose the greatest health risks. Eight of the 16 US EPA prioirty PAHs were targetted as losses of lower ring PAHs are common at low temperatures and PAHs containing 4 or more rings are more commonly created through combustion processes.

The results of this investigation indicates that the De-Wipe is effective at removing dioxins and PAHs from skin.

Pollutant	**Average % removal**
Most Harmful Chlorinated Dioxin (tested 17)	99 %
Most Harmful PAH (tested 8)	90 %

Pollutant	**% removal**
Dibenzo(a,h)anthracene	94 %
Benzo(a)pyrene	92 %
2,3,7,8 TCDD - Tetrachlorodibenzodioxin	98 %
2,3,4,7,8 PeCDF - Pentachlorodibenzofurans	81 %

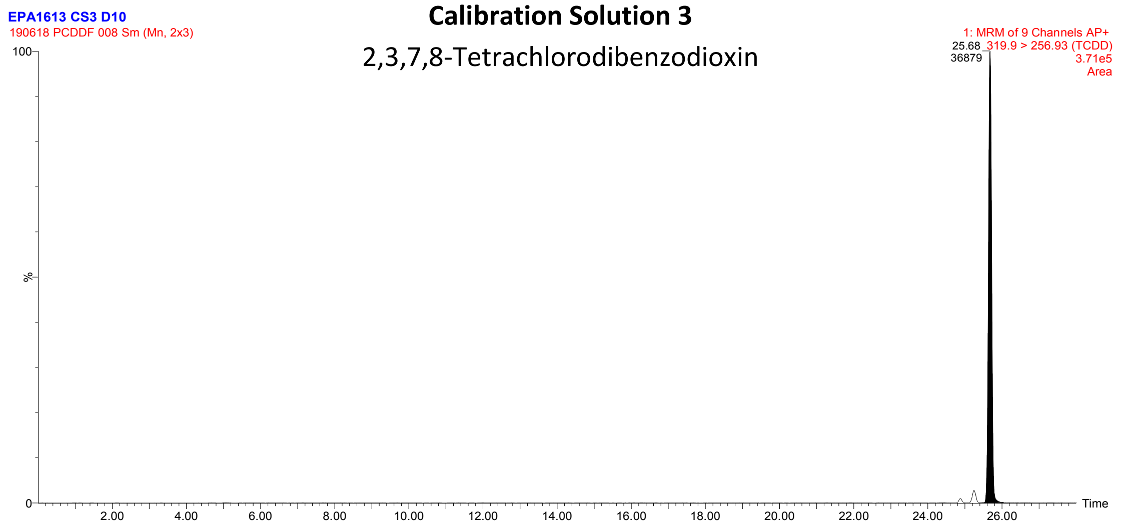
De-Wipe report (R/DW001/F) chromatogram sample data

2,3,7,8-Tetrachlorodibenzodioxin

EPA-1613STOCK (supplied by Wellington Laboratories Inc., Canada): *U.S. EPA Method 1613 Native PCDD/PCDF Stock Solution/Mixture*

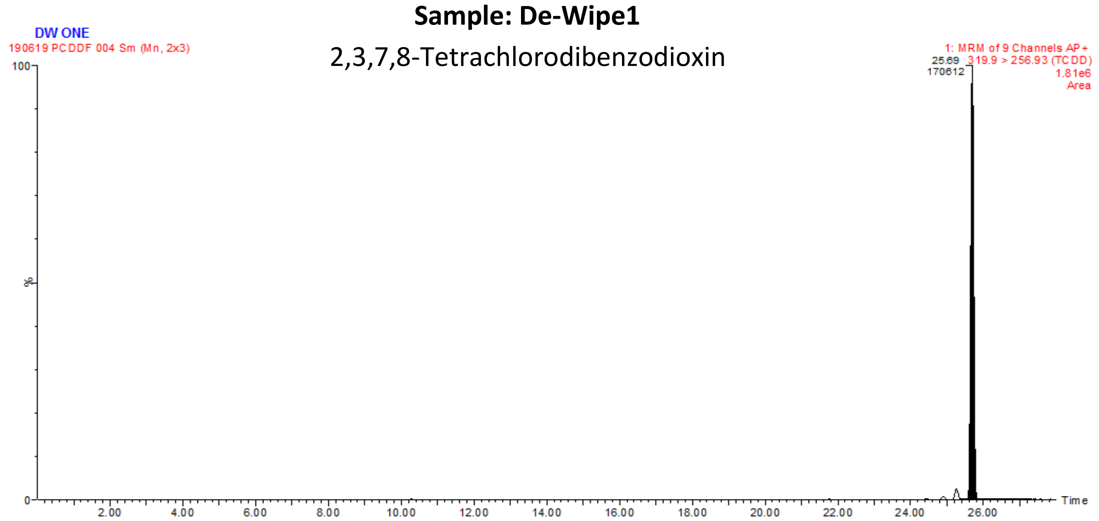
Calibration Solution 3

2,3,7,8-Tetrachlorodibenzodioxin



Sample: De-Wipe1

2,3,7,8-Tetrachlorodibenzodioxin



Analysed by	Authorised by	Manchester Metropolitan University
Daniel Niepsch 18&19th June 2019	Dr David Megson 6th August 2019	

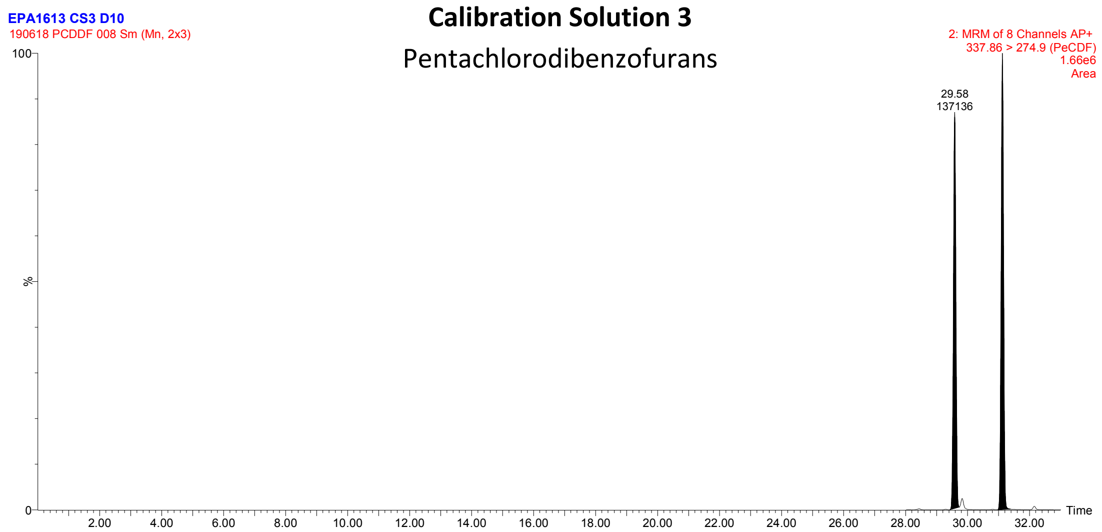
De-Wipe report (R/DW001/F) chromatogram sample data

Pentachlorodibenzofurans

EPA-1613STOCK (supplied by Wellington Laboratories Inc., Canada): *U.S. EPA Method 1613 Native PCDD/PCDF Stock Solution/Mixture*

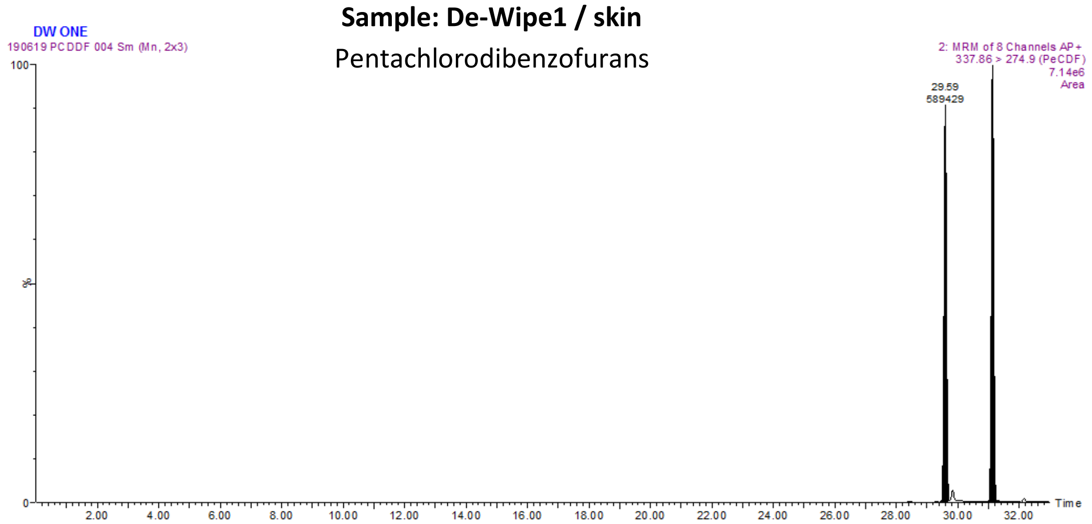
Calibration Solution 3

Pentachlorodibenzofurans



Sample: De-Wipe1 / skin

Pentachlorodibenzofurans



Peak 1: 1,2,3,7,8-PeCDF
Peak 2: 2,3,4,7,8-PeCDF

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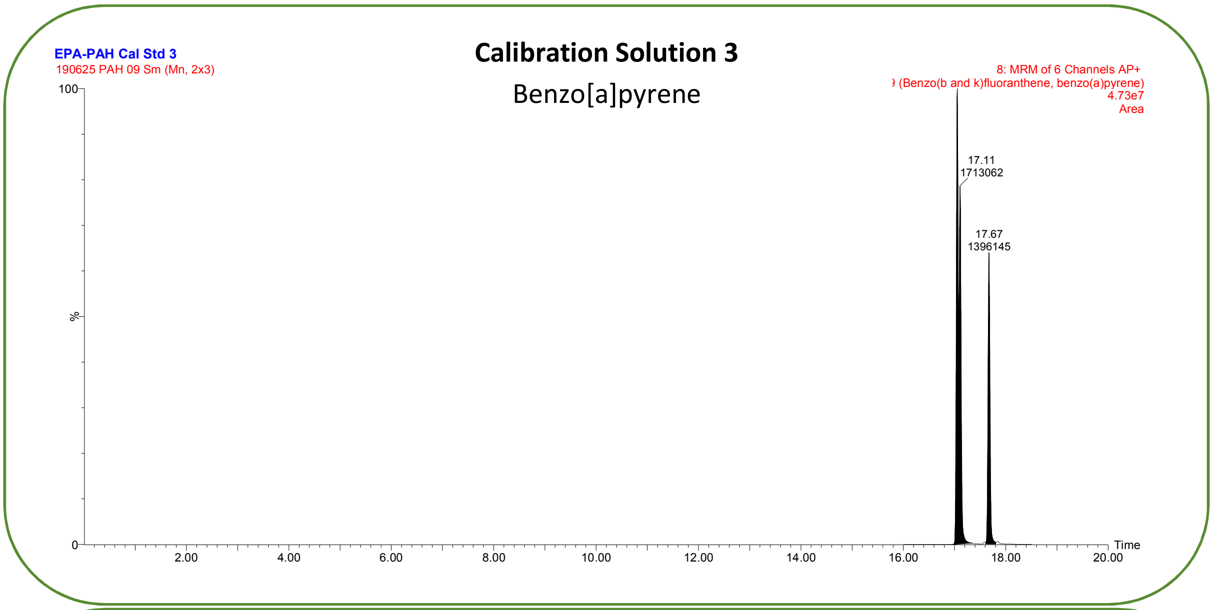
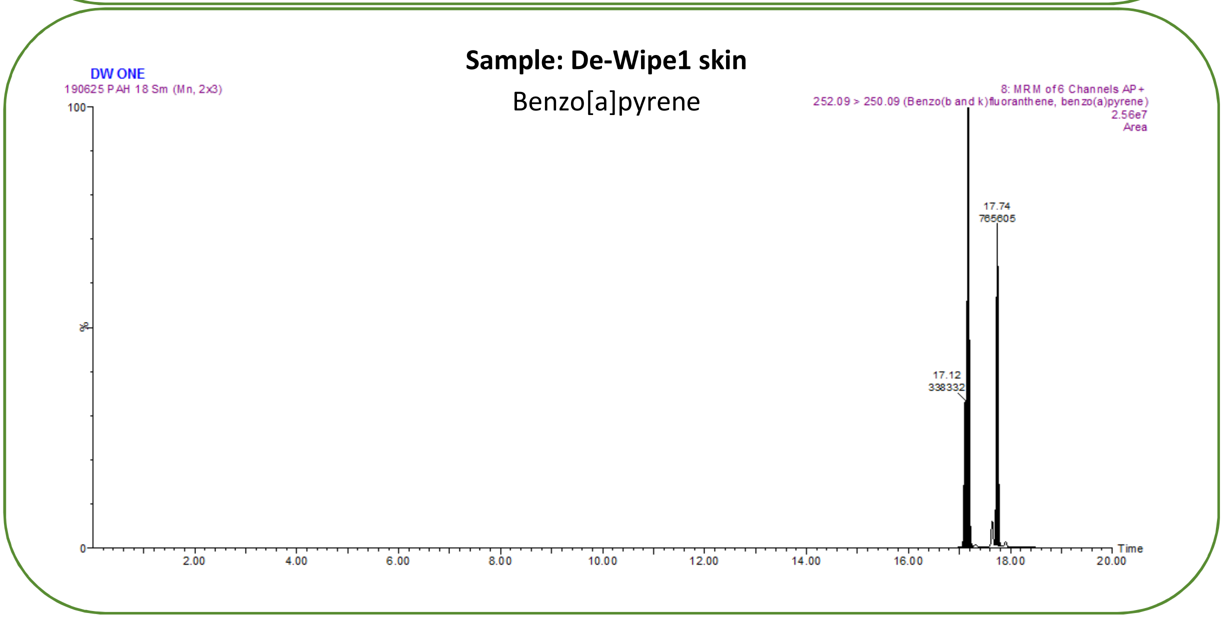
De-Wipe report (R/DW001/F) chromatogram sample data

Benzo[a]pyrene

EPA-PAH-STK (supplied by Wellington Laboratories Inc., Canada): *Polycyclic Aromatic Hydrocarbon (PAH) Native Stock Solution*





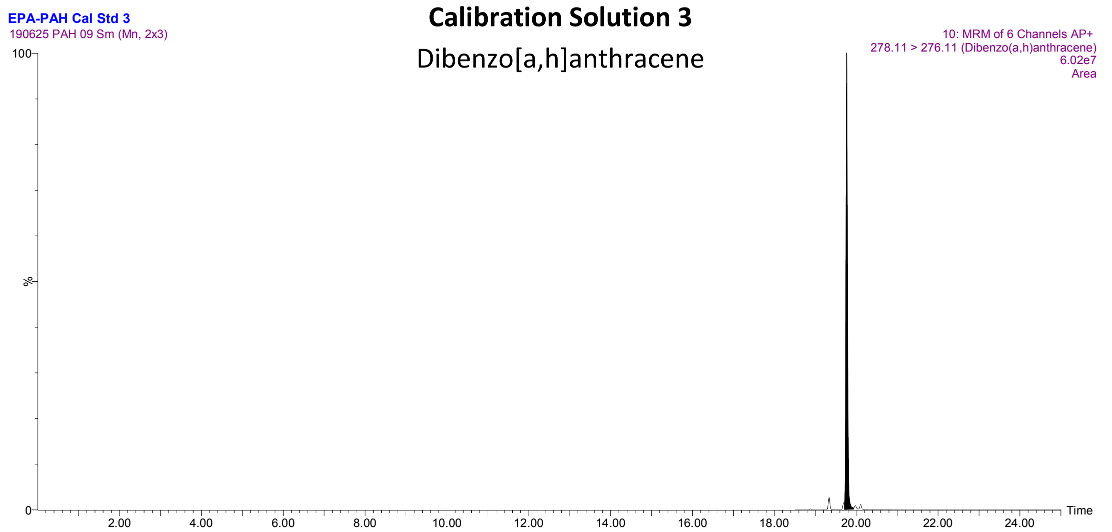
Peak 1: Benzo[b]fluoranthene
Peak 2: Benzo(k)fluoranthene
Peak 3: Benzo[a]pyrene

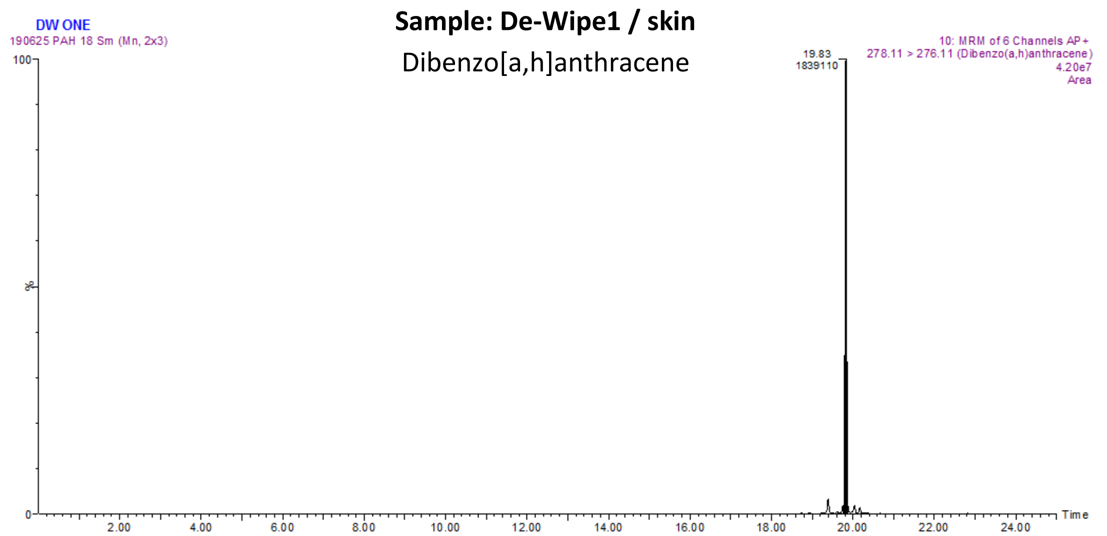
Analysed by	Authorised by	
Daniel Niepsch 25th June 2019	Dr David Megson 6th August 2019	Manchester Metropolitan University

De-Wipe report (R/DW001/F) chromatogram sample data

Dibenzo[a,h]anthracene

EPA-PAH-STK (supplied by Wellington Laboratories Inc., Canada): *Polycyclic Aromatic Hydrocarbon (PAH) Native Stock Solution*





Analysed by	Authorised by	Manchester Metropolitan University
Daniel Niepsch 25th June 2019	Dr David Megson 6th August 2019	

(4) Conclusions and recommendations

These results are highly encouraging and conclude that the De-Wipe is able to remove dioxins and PAHs from skin.

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