

Vehicle Interior Air Quality: Volatile Organic Compounds

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Background

National Air Quality Testing Services (NAQTS) is a social business that is passionate about improving the quality of life.

We seek to improve awareness of indoor air quality (IAQ) through widespread public and commercial monitoring. The challenges for Vehicle Interior Air Quality (VIAQ) are similar and these studies are jointly done with Emissions Analytics.

We believe that understanding your indoor air quality is a holistic enterprise, utilising affordable integrated testing equipment.

Based in UK (Lancaster University Environment Centre and Cardiff), and in Ann Arbor, Michigan, USA.

Technology

PN - CPC with 20:1 pre-dilution (IPA, d_{50} 15nm)

CO, NO₂ - Multiple Electrochemical and Metal Oxide sensors

VOCs - Electrochemical, Metal Oxide and Thermal desorption tubes for GC-MS Analysis.

CO₂ - NDIR

T, P, RH - BME280

Noise - dBA

Location - GPS

Vibration - 3D accelerometer and 3D Gyro

Web GUI with SQL Database



Indoor



Outdoor

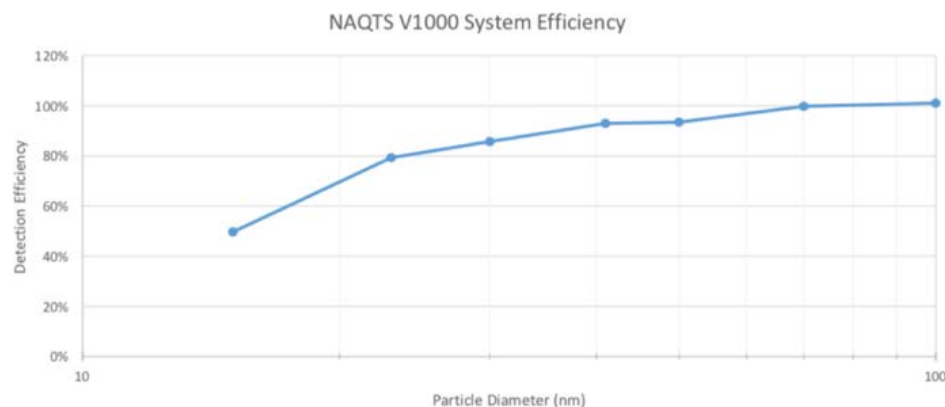


In-Vehicle

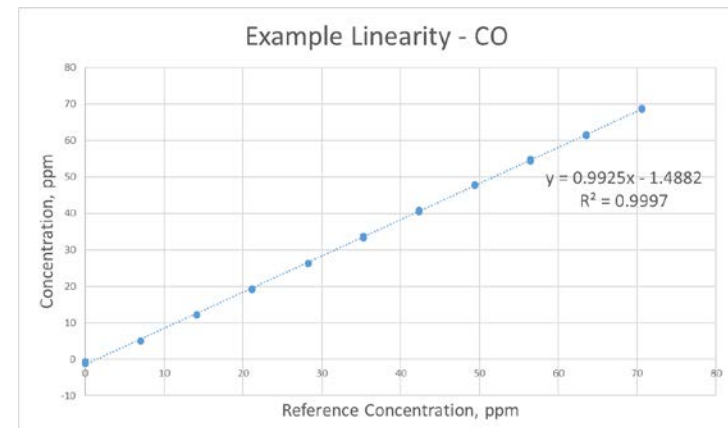
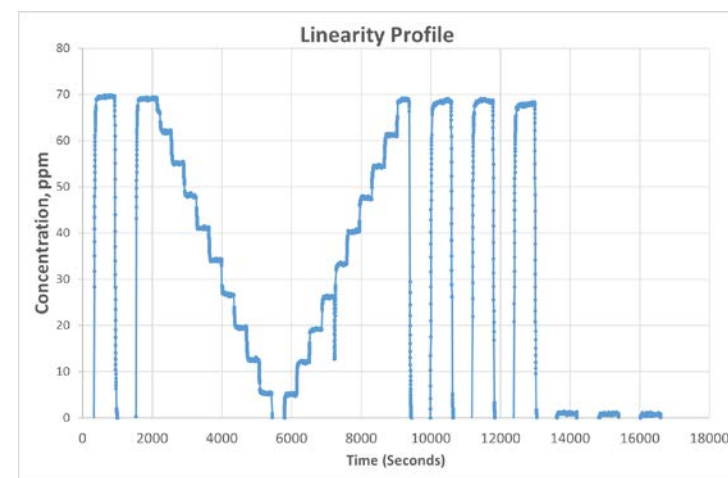
Metrology

PN Calibration in accordance with ISO 27891

CERTIFICATE OF CALIBRATION			
ISSUED BY Ricardo-AEA Ltd trading as Ricardo Energy & Environment			
DATE OF ISSUE	15/02/2018	CERTIFICATE NUMBER	PMC328
 Ricardo Energy & Environment Particle Measurement Centre Unit 2 Ludbridge Mill Reading Road, East Hendred Wantage, Oxfordshire OX12 8LN, UK		 0401	
Page 1 of 4 pages			
Approved Signatory		Name	
Signature			
Telephone: 01235 861343		Email: PMC.EE@Ricardo.com	
Web: ee.Ricardo.com			
Customer :		To: National Air Quality Testing Services Ltd	
Address :		Lancaster Environment Centre, Lancaster University, LA1 4YQ	



Gas calibration (Zero/span linearity)



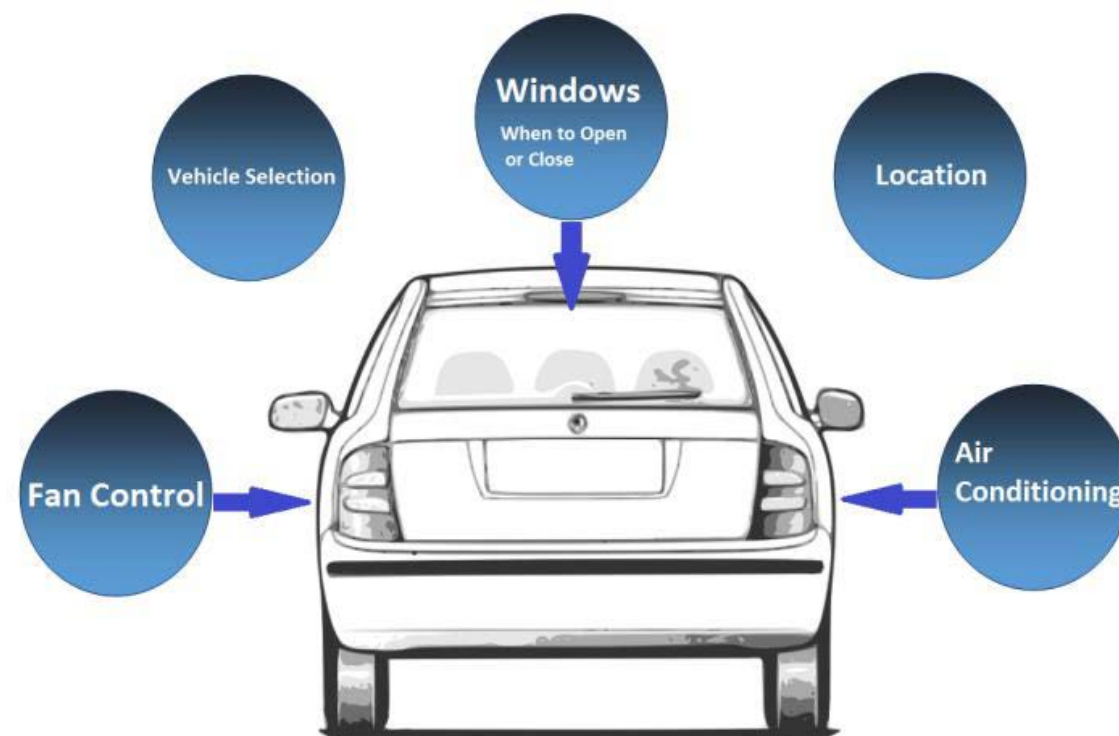
The Problem

101 minutes per day in vehicles (Dong et al. 2004)

Immediate proximity to significant pollutant sources (other vehicles), plus in urban areas, high outdoor concentrations

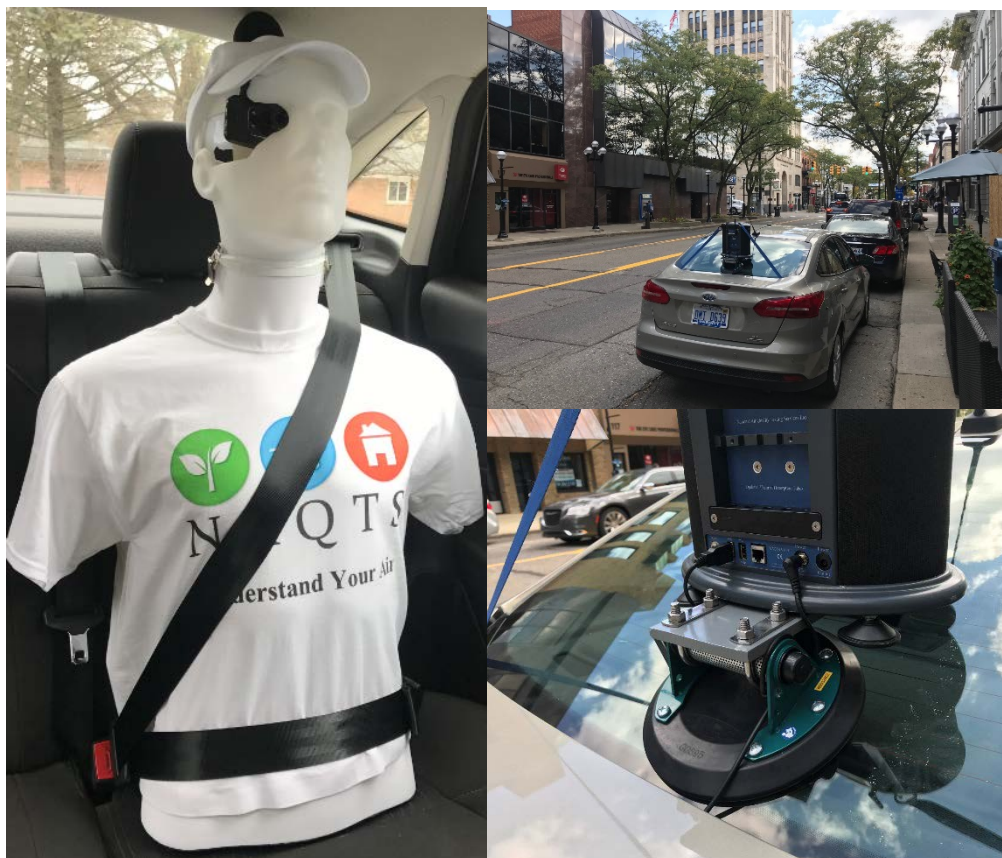
Key questions:

1. How much ambient air pollution is coming into the vehicle?
2. What are the in-vehicle sources of air pollution?

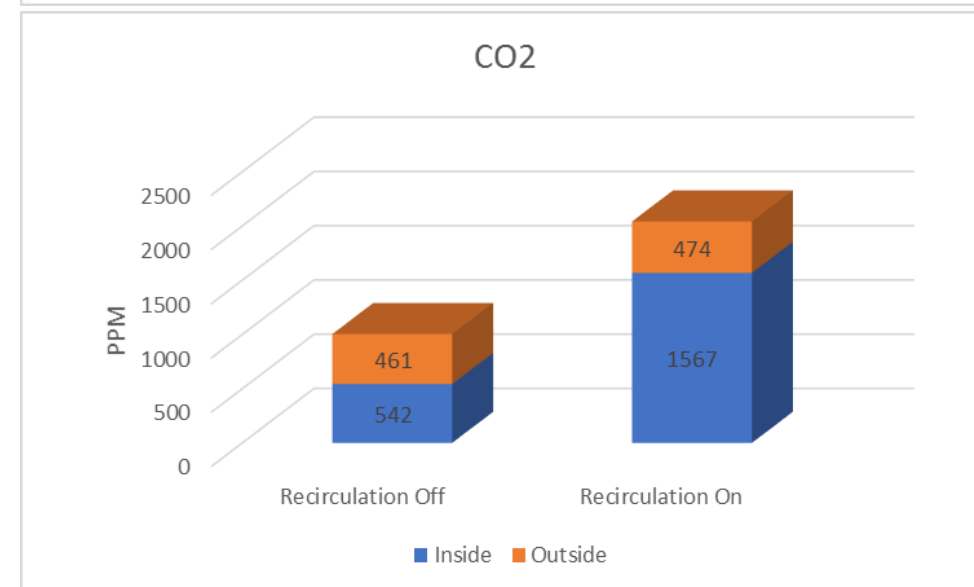
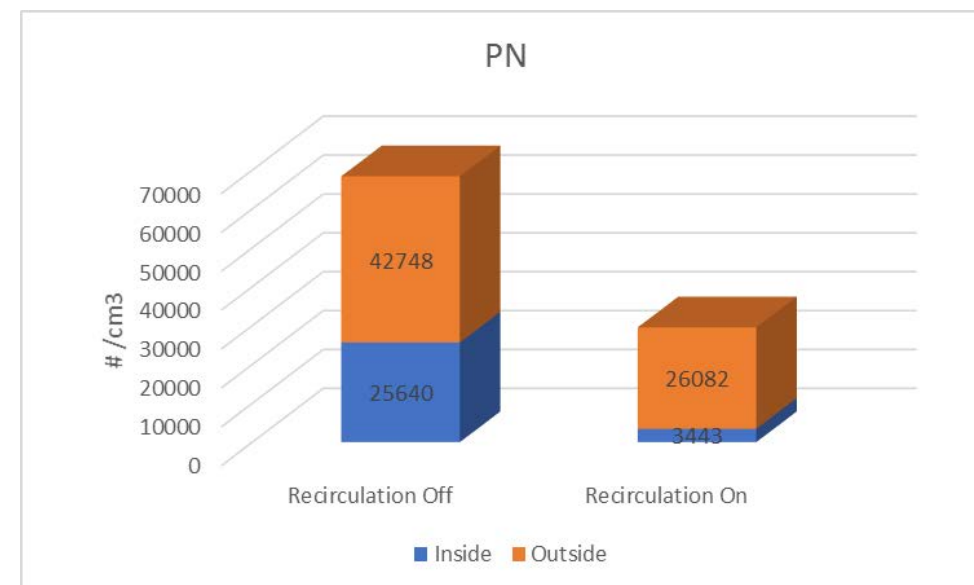


(Müller et al. 2011)

Q1: Ambient Ingress



	INGRESS RATIO	STUFFINESS FACTOR
Recirculation Off	60%	1.2
Recirculation On	13%	3.3

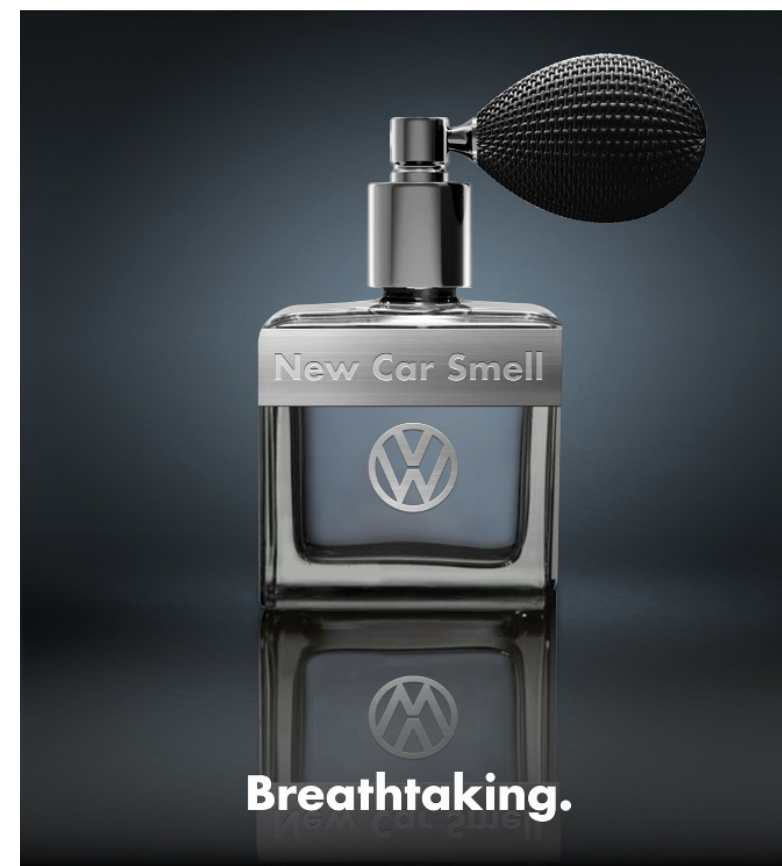


Q2: Vehicle Interior Pollutants

Volatile Organic Compounds (VOCs), responsible for the “new car smell”, can be emitted from an array of interior parts and components: the dashboard, interior panels, flooring materials, and many others.

Within the confined space of a vehicle, VOCs emitted from these components may reach levels that are potentially harmful to human occupants, causing symptoms such as nausea, allergies, fatigue, stinging eyes, and headaches.

Beyond affecting drivers’ and passengers’ well-being and comfort, such symptoms may have also consequences on safe driving



The new 2011 SportWagen.
40 mpg hwy, starting at \$23,000.



Regulatory Context

Who is setting standards?

- **Automobile Associations** (JAMA, ACEA, TÜV Rhineland Group etc.)
- **Manufacturers** (GM, BMW, VW, etc.)
- **ISO** (ISO 12219-1 – ISO 12219-7)

Monitoring techniques?

- **Environmental Chambers** (BMW GS97014-3, ISO 12219-3 - ISO 12219-5)
- **Bag method** (TSM0508G, ISO 12219-2)
- **TD GC-MS** (PB VWL 709; VDA 278)

What are they monitoring?

- Interior materials (GMW15634)
- Full vehicle (GMW15654, ISO 12219-1)

Move towards harmonisation...

“Shall include provisions and harmonized test procedures for the measurement of interior VOCs taking into account existing standards”



UNECE

Experimental Set-Up (Static Baseline)



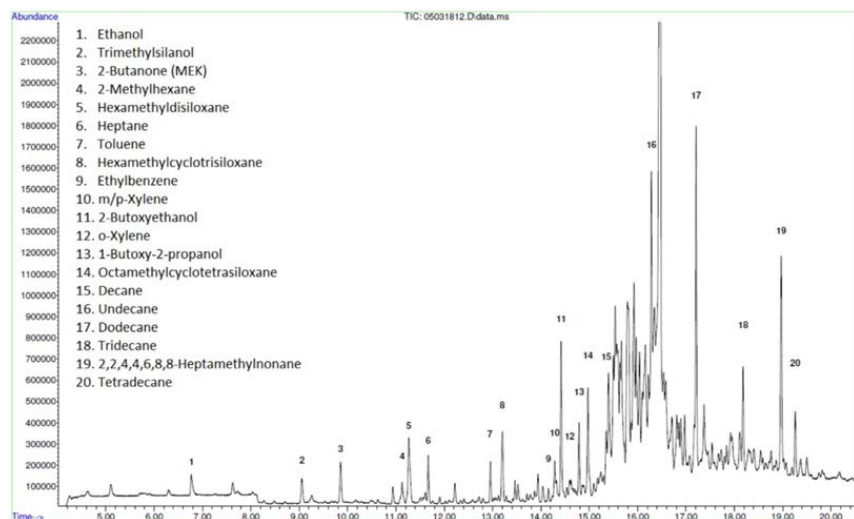
Hydrophobic TnxTA/Cg1



Integrated into NAQTS V1000



Tested inside Emissions Analytics' Stokenchurch Emissions Lab



Top 20 peaks, Semi-quantitative (spiked with d8-Toluene, d6-benzene and d4-dichlorobenzene)



Agilent GC-MS, samples run on full scan mode



Thermal Desorption



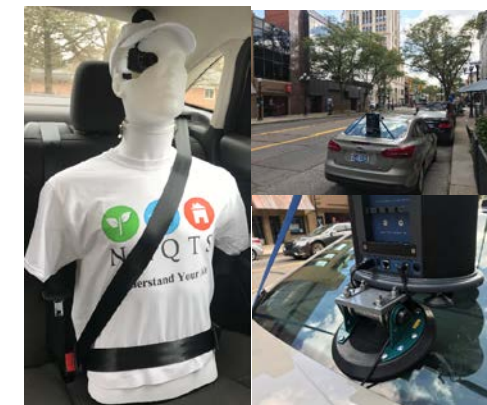
Experimental Set-Up (Real World Driving)



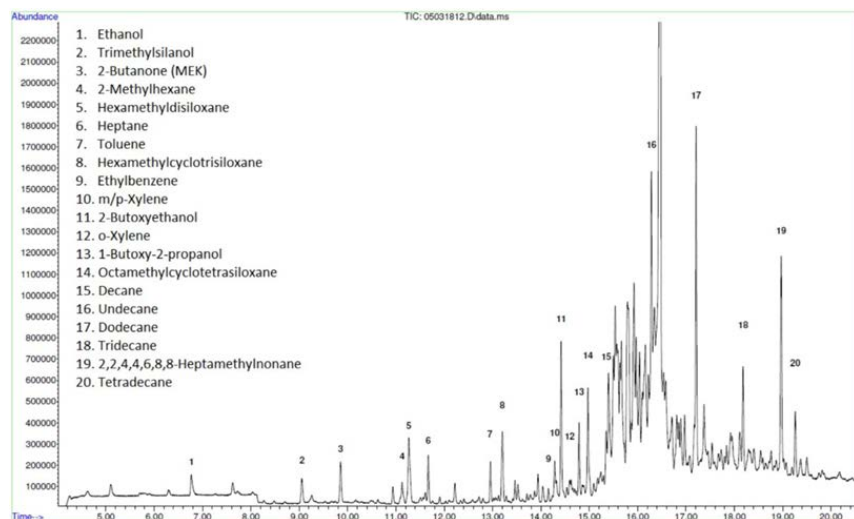
Hydrophobic TnxTA/Cg1



Integrated into NAQTS V1000



Tested dynamically on RDE-type route (Geofencing – Urban, Rural, Highway etc.) at same time as indoor-outdoor research to see VOCs ingress



Top 20 peaks, Semi-quantitative (spiked with d8-Toluene, d6-benzene and d4-dichlorobenzene)

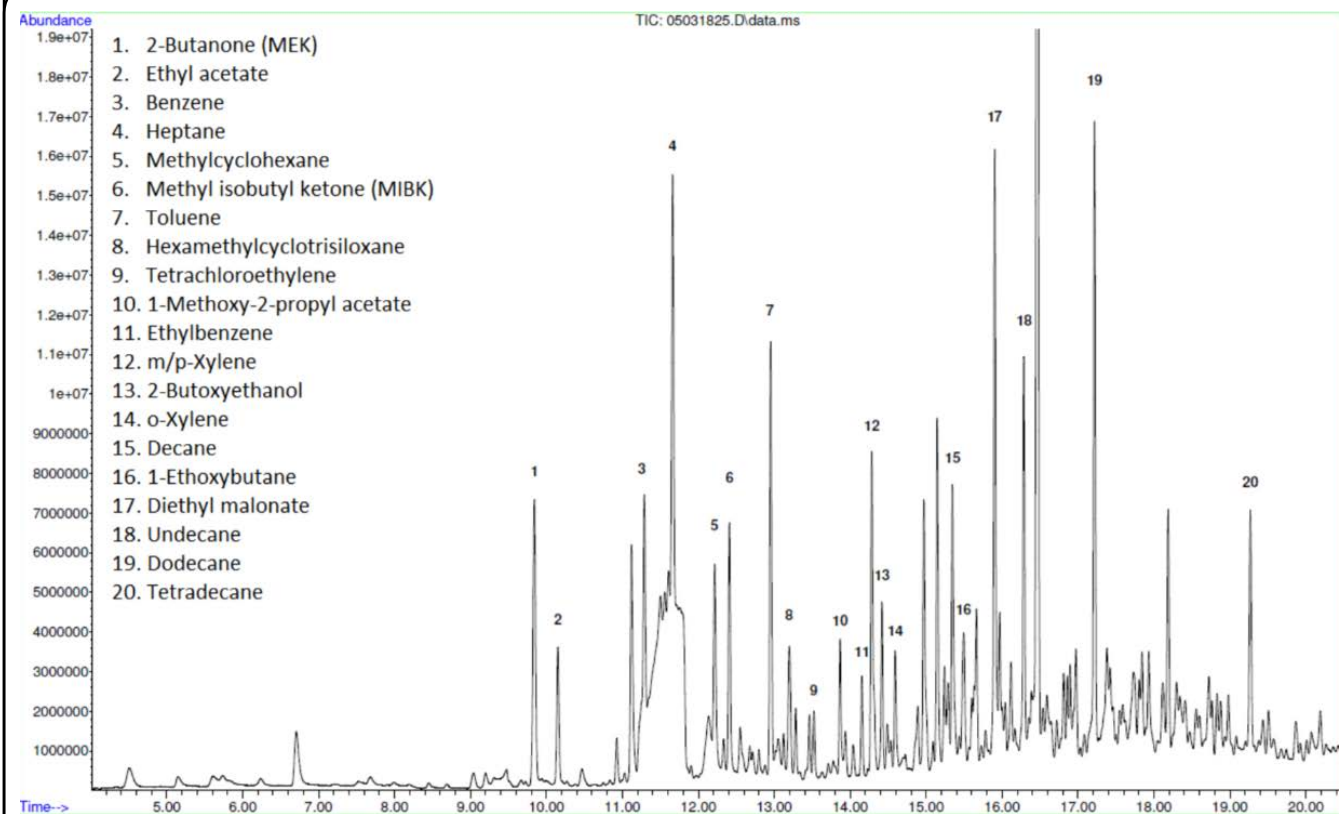
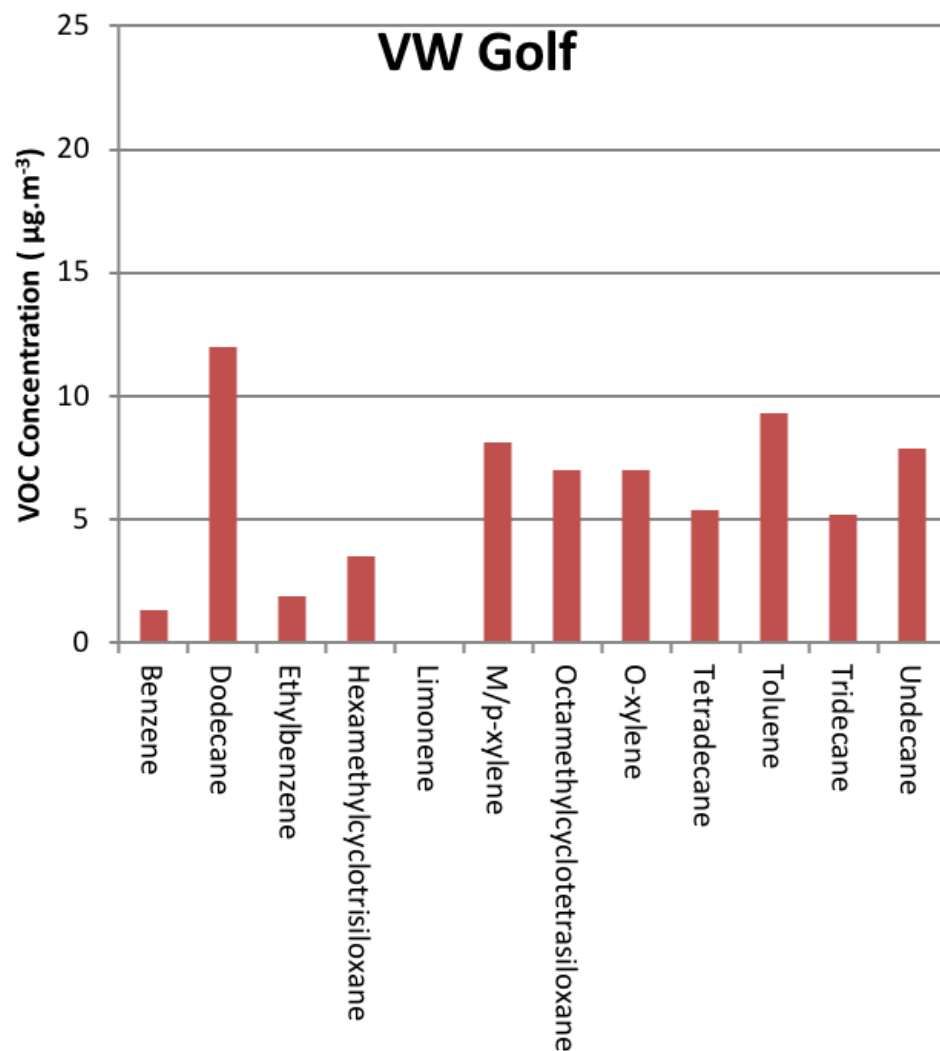


Agilent GC-MS, samples run on full scan mode

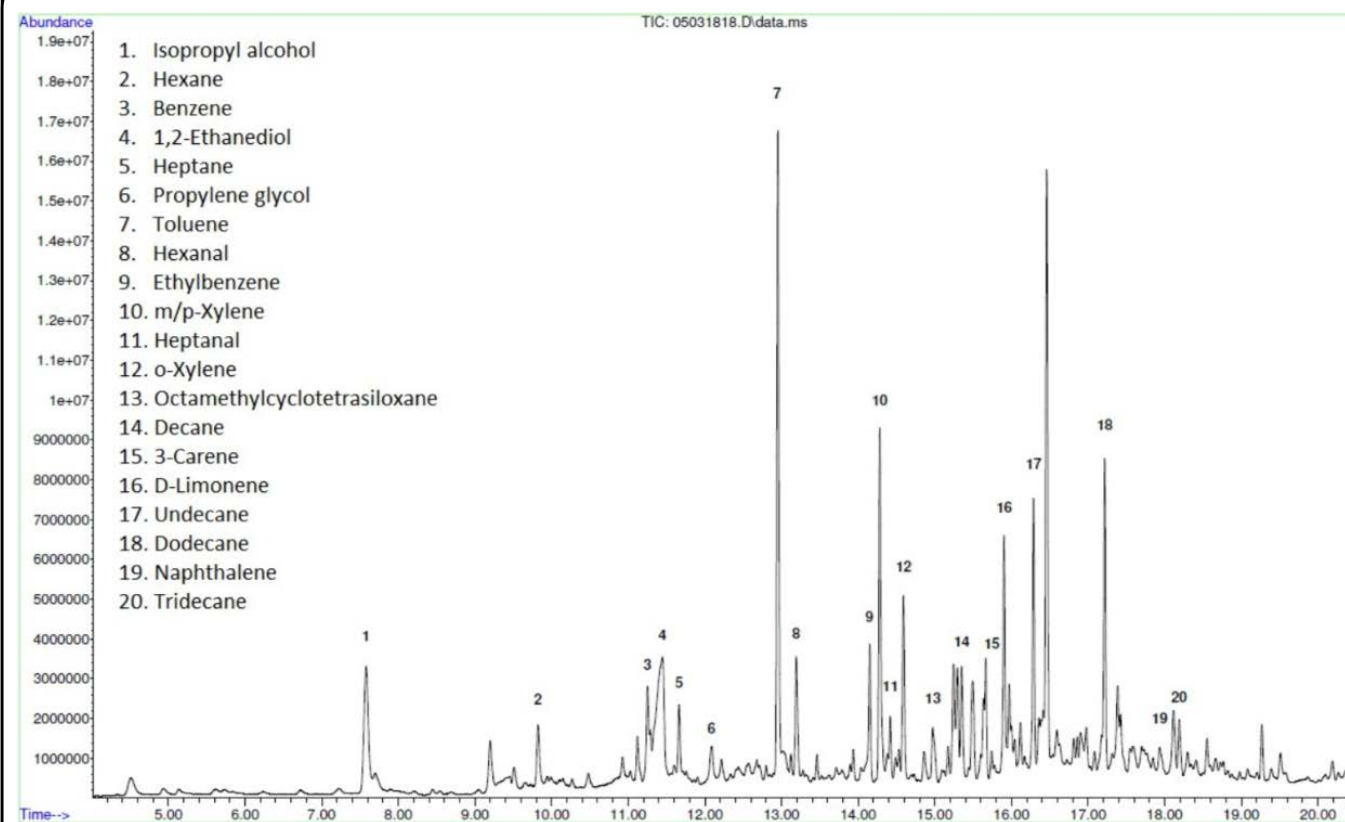
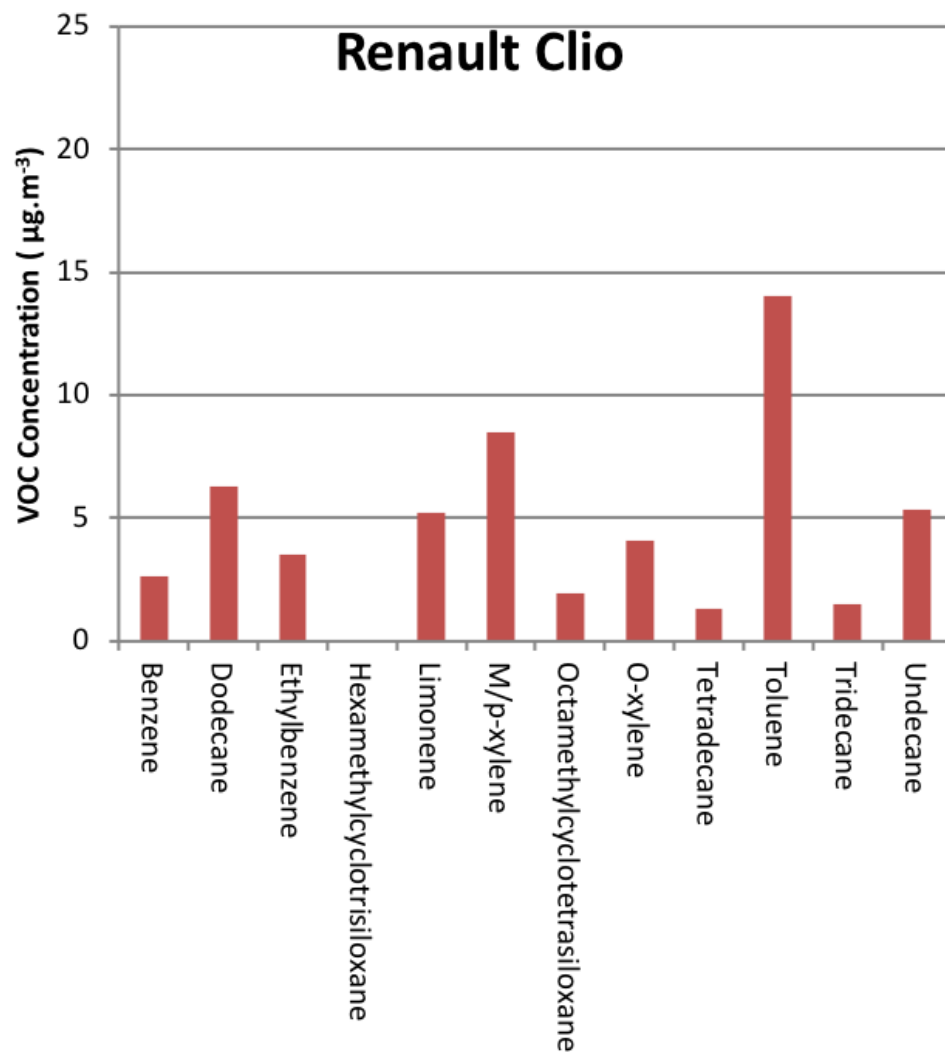


Thermal Desorption

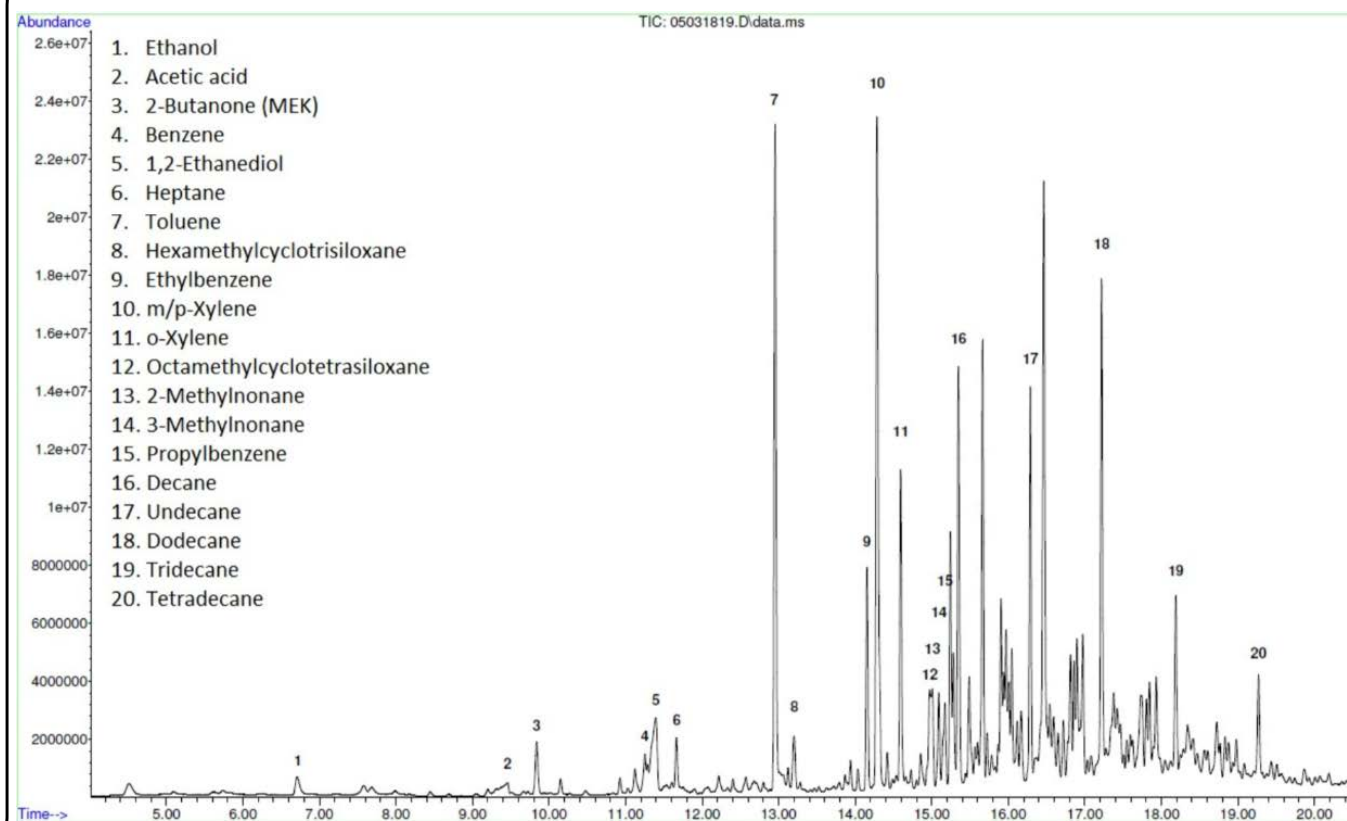
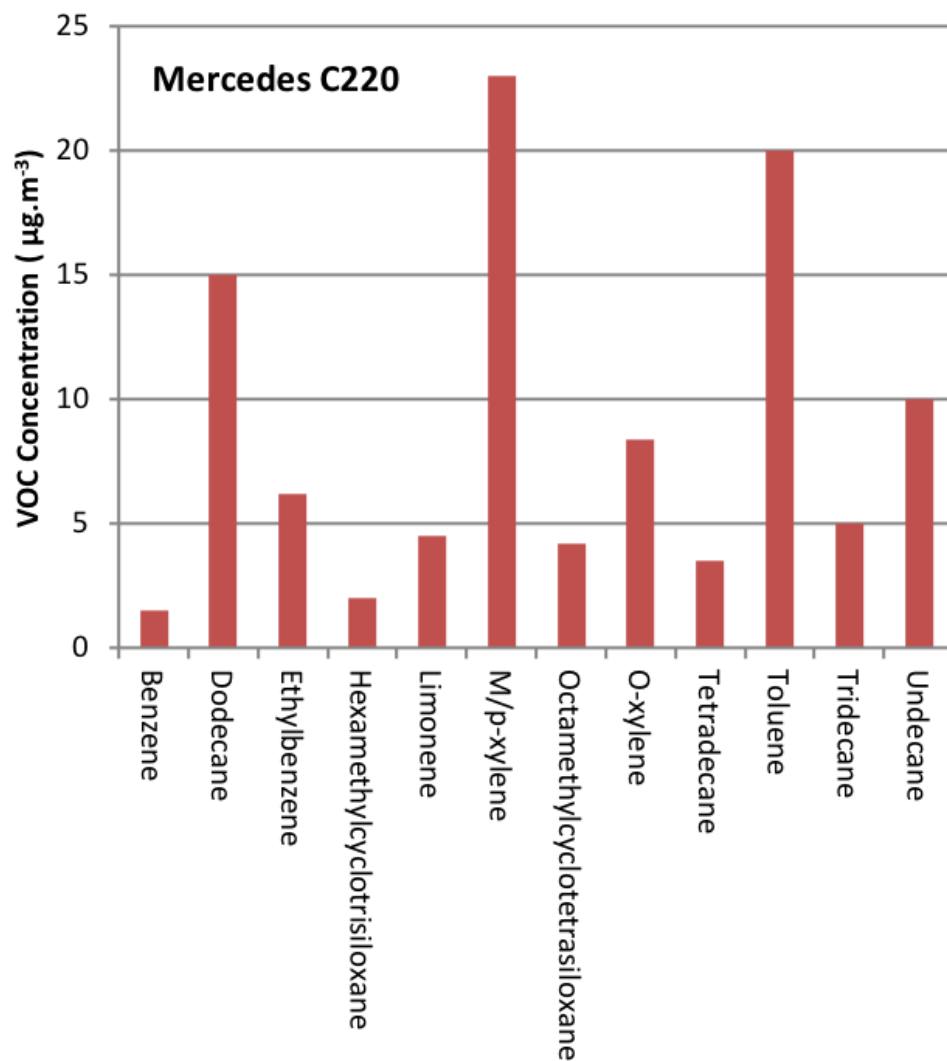
VW Golf (2011)



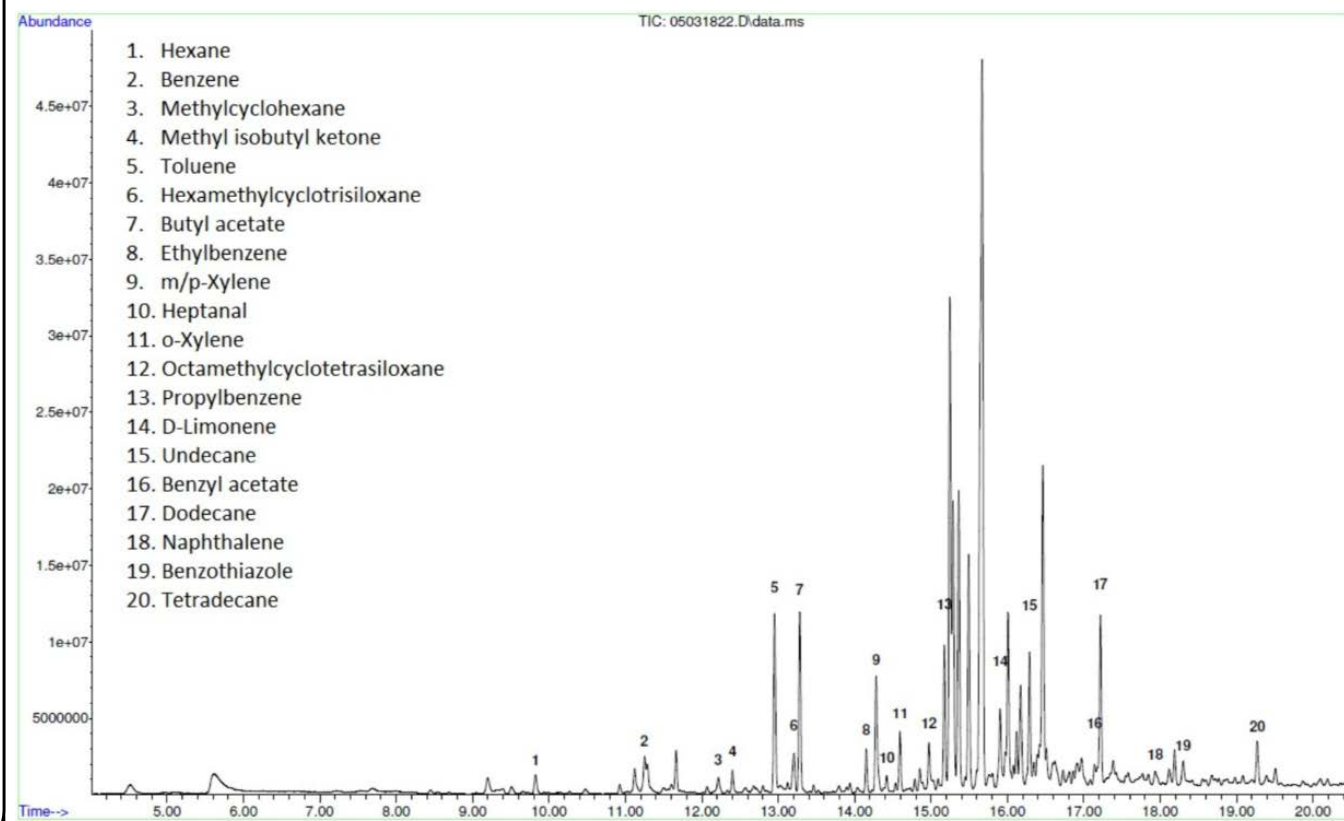
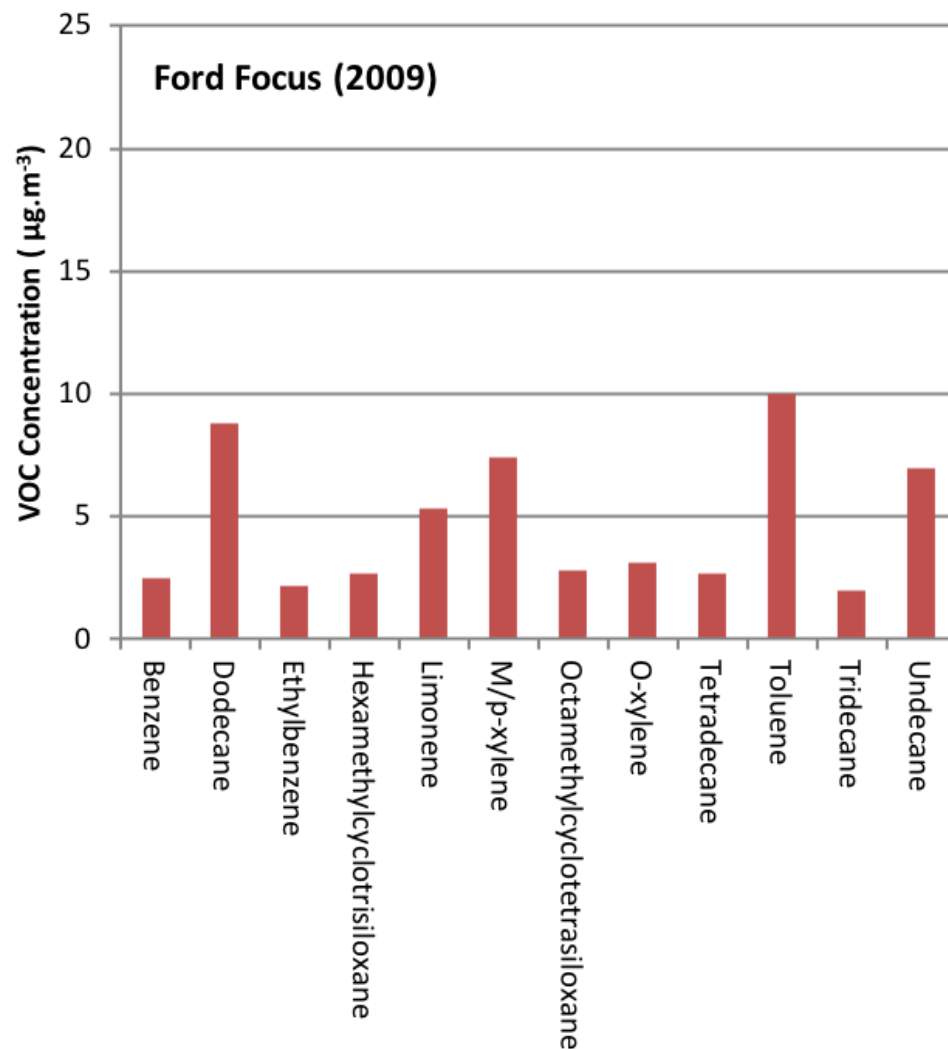
Renault Clio (2016)



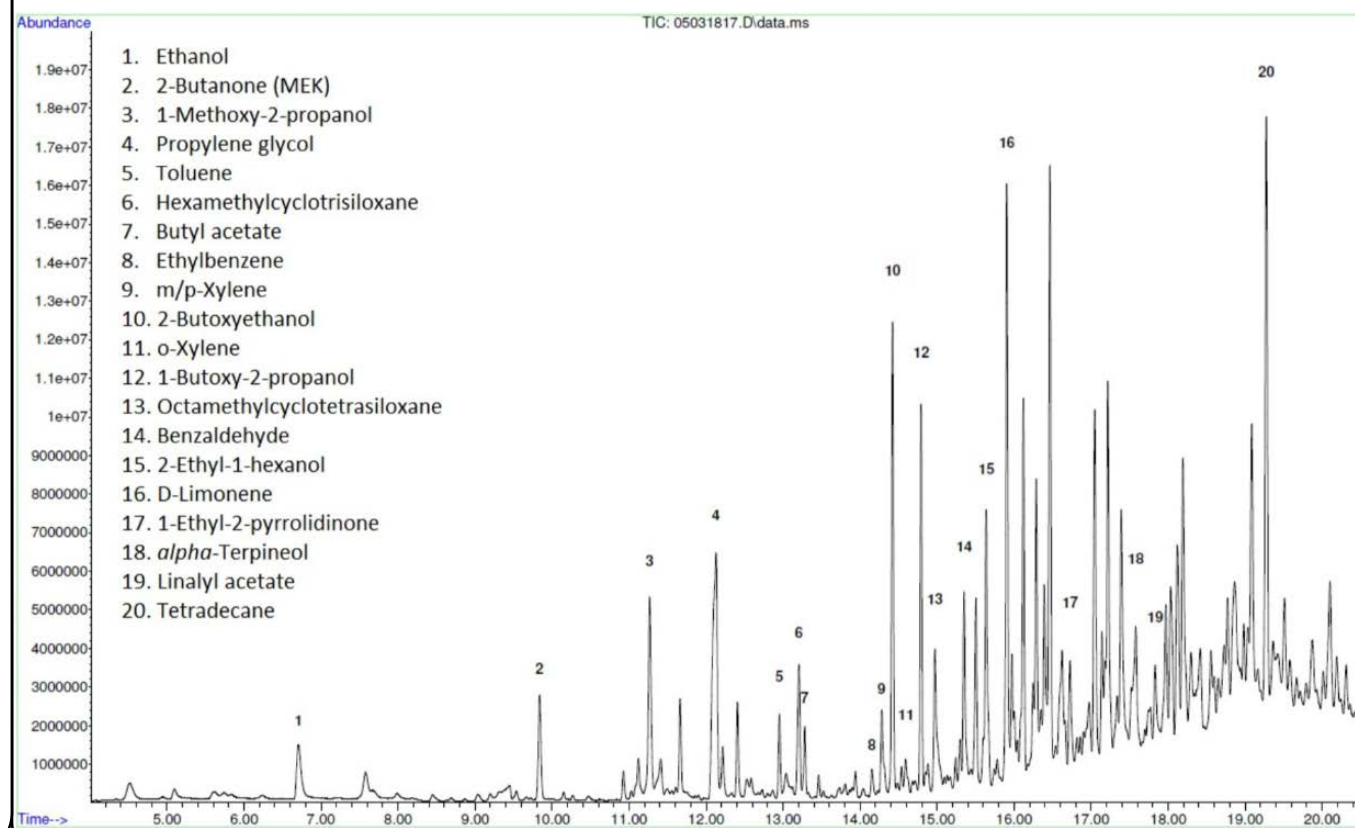
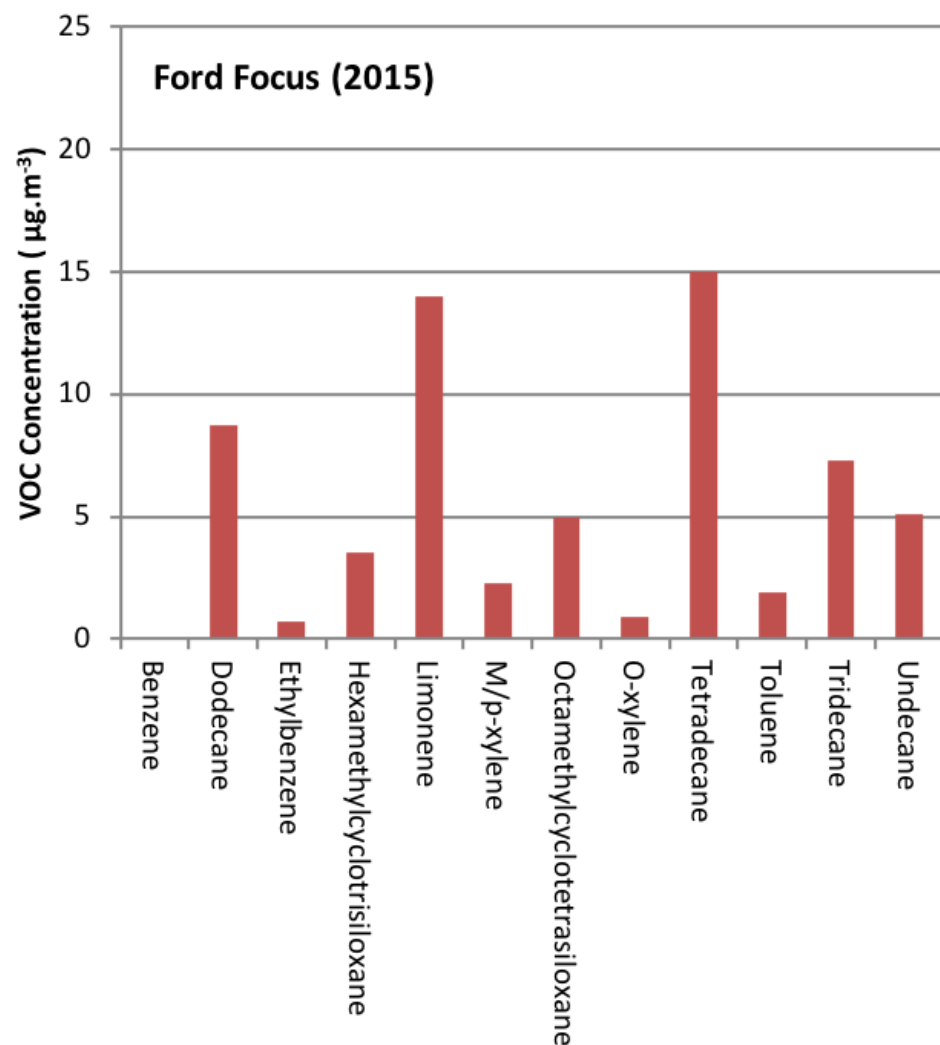
Mercedes C220 (2005)



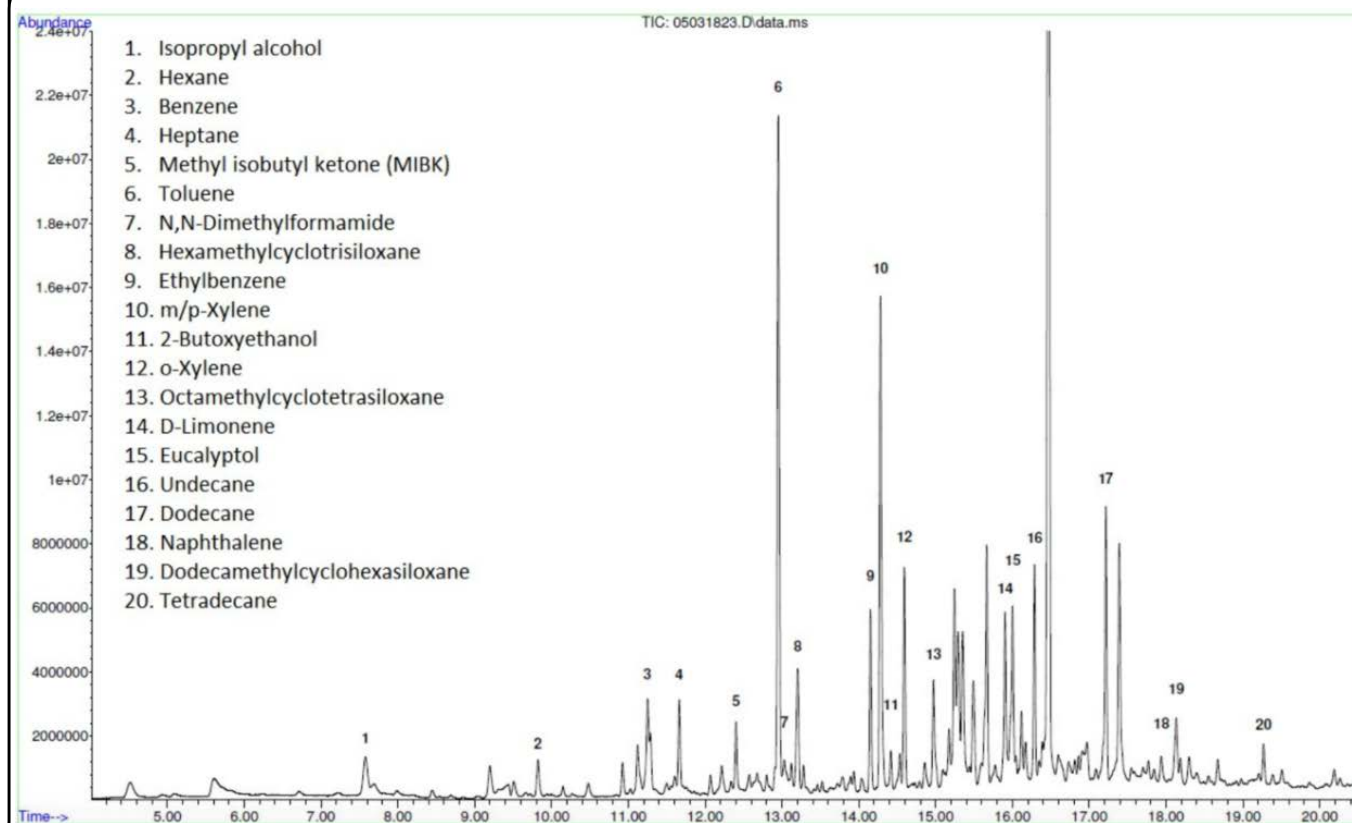
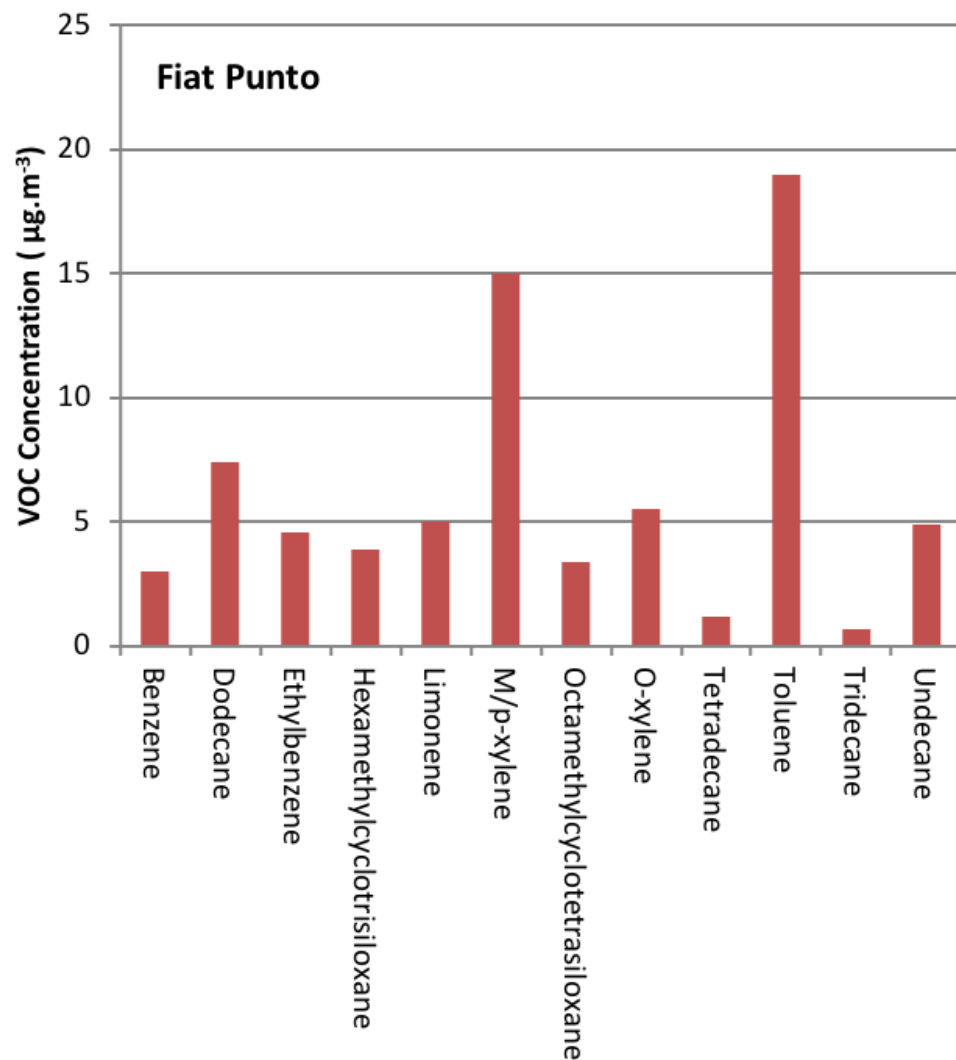
Ford Focus (2009)



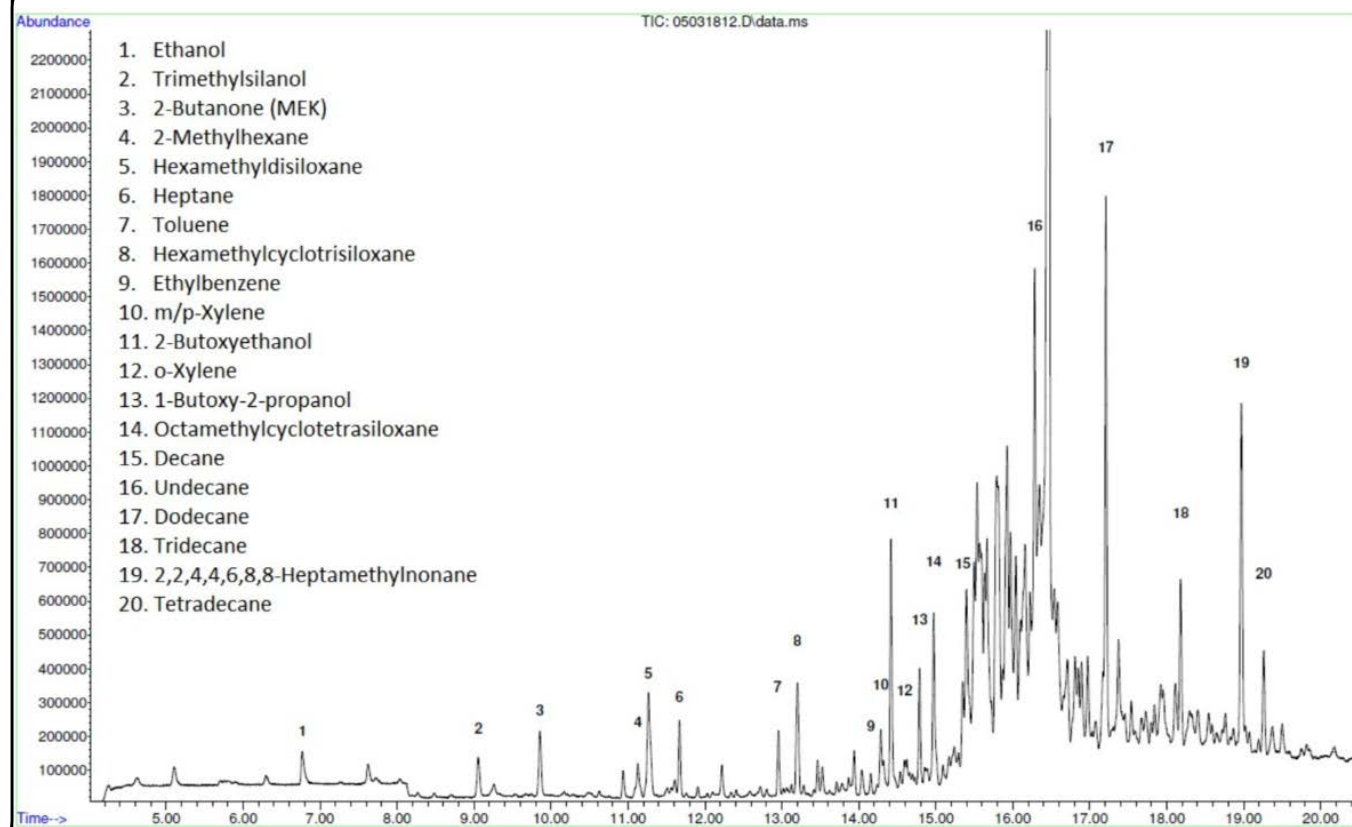
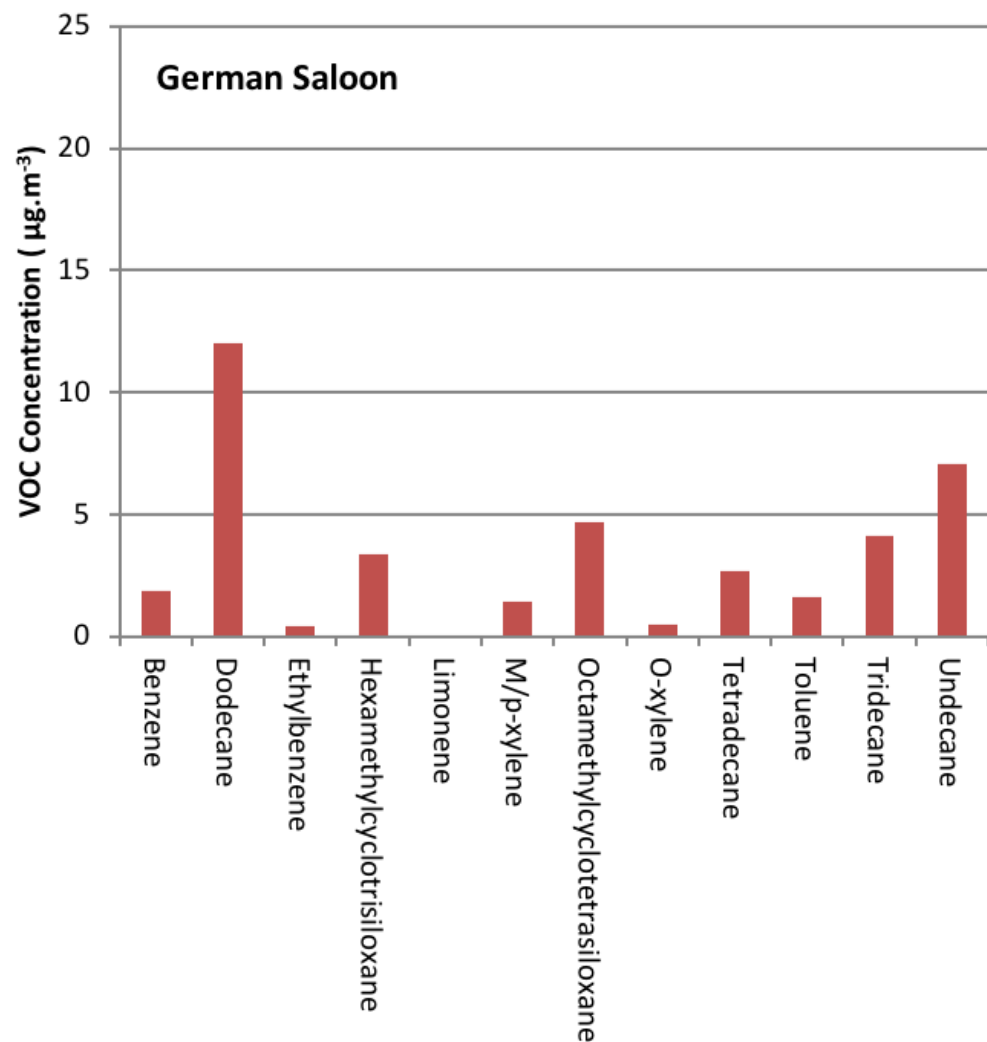
Ford Focus (2015)



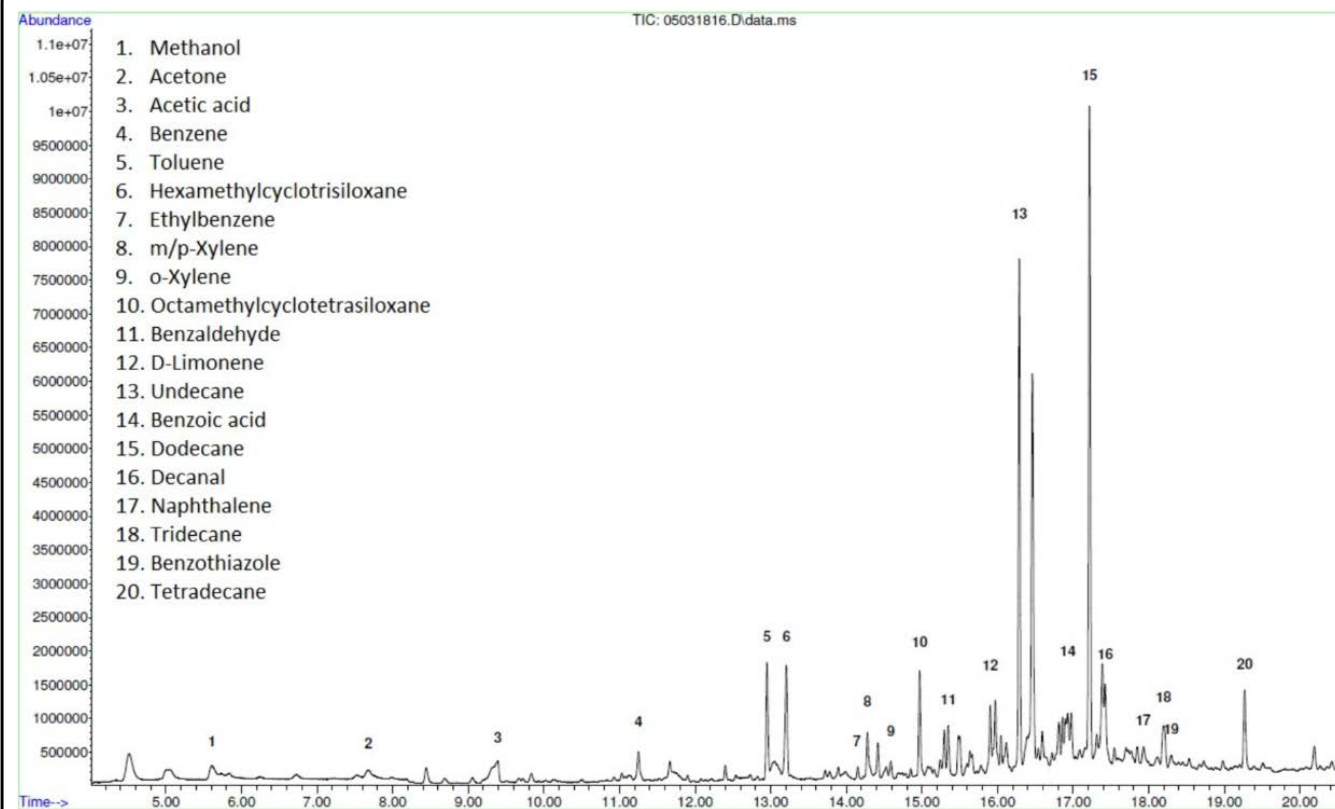
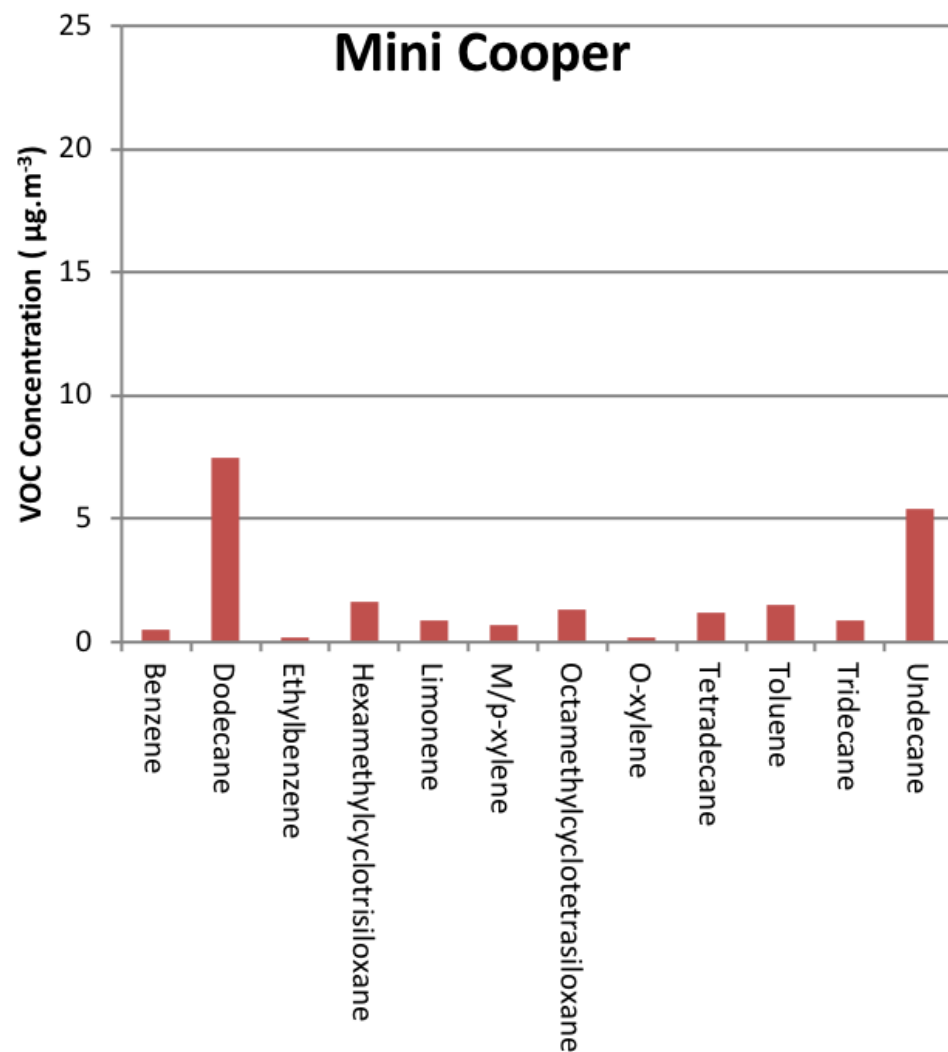
Fiat Punto (2008)



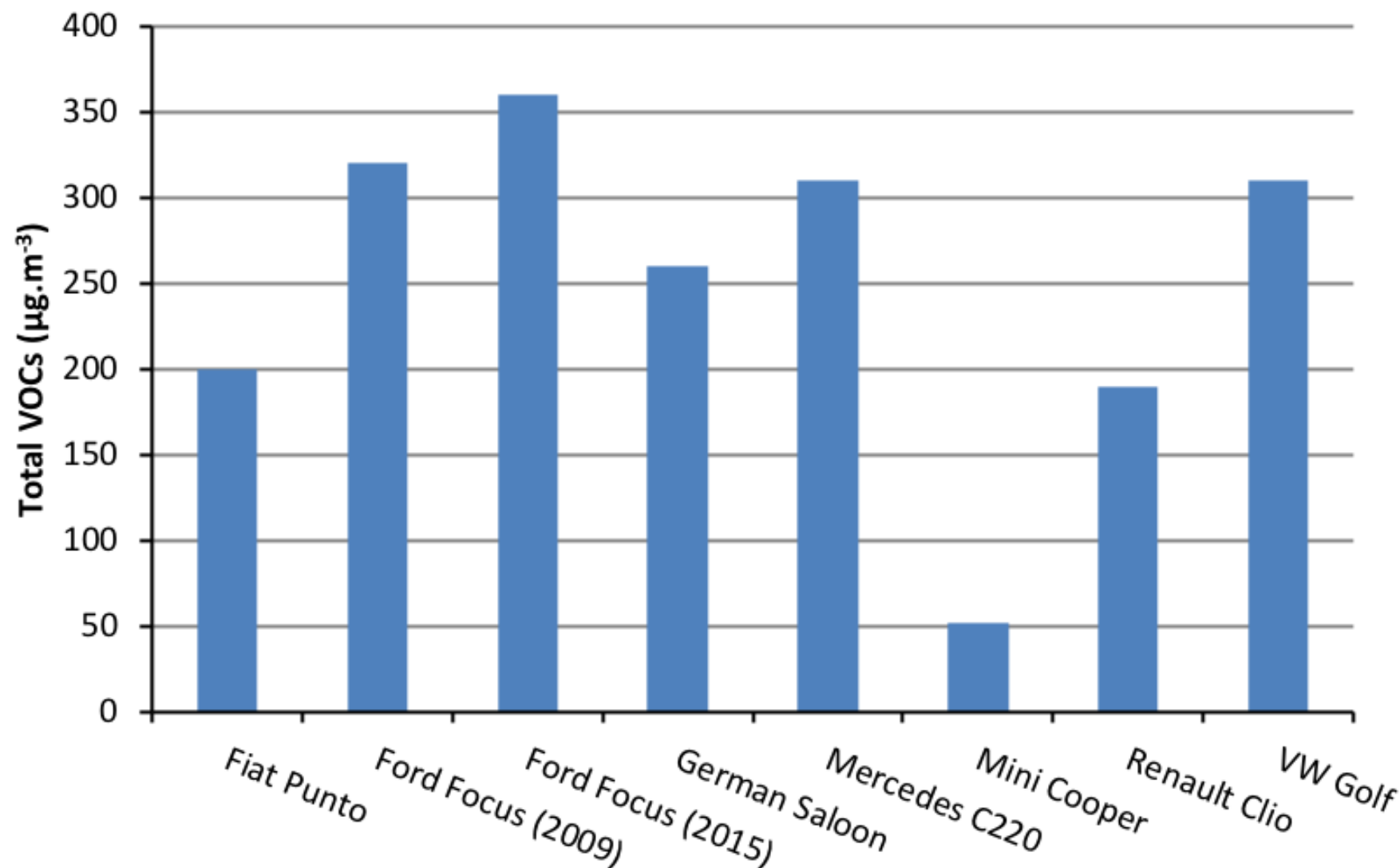
German Saloon (2017)



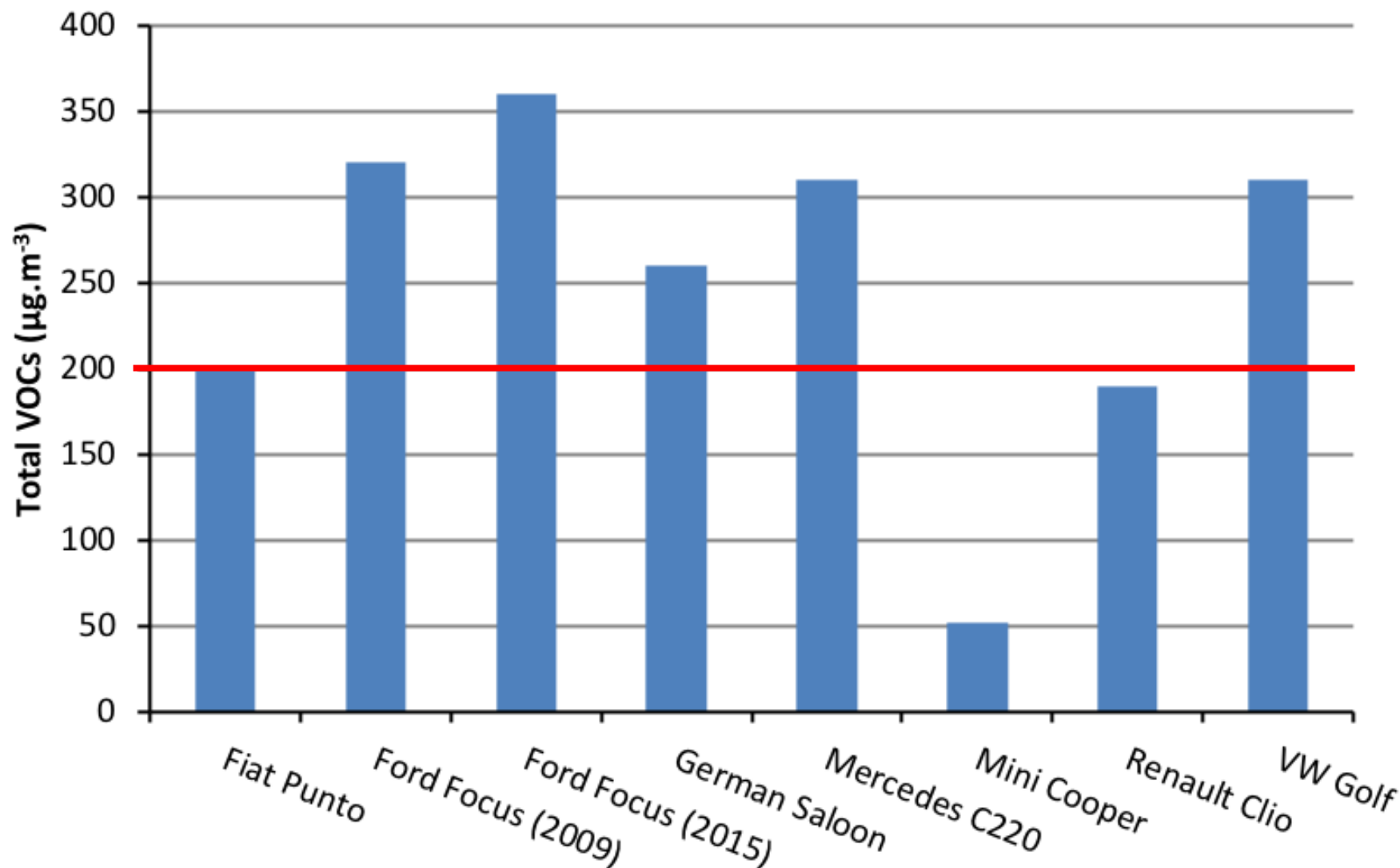
Mini Cooper (2006)



Comparisons - TVOCs

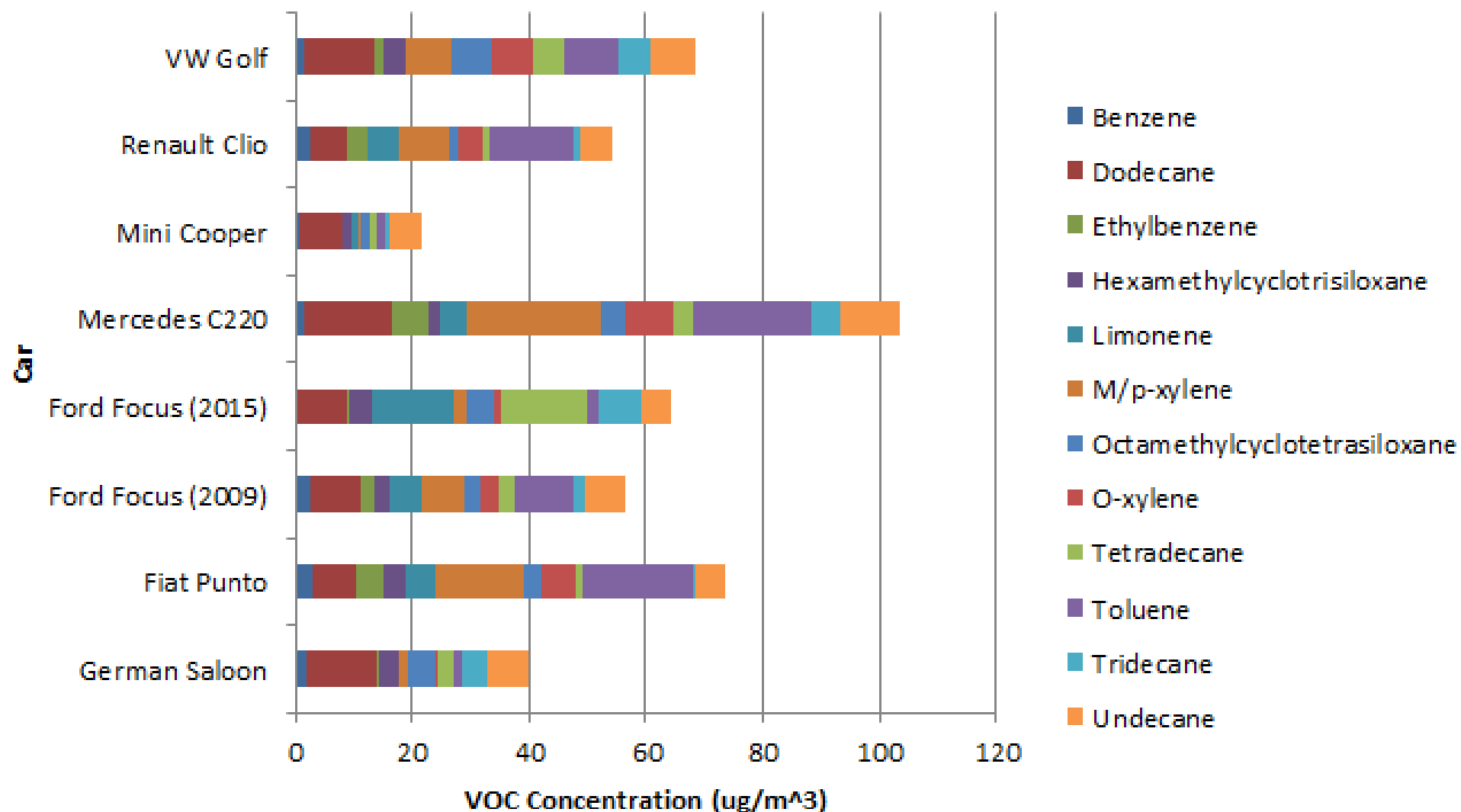


Comparisons - TVOCs

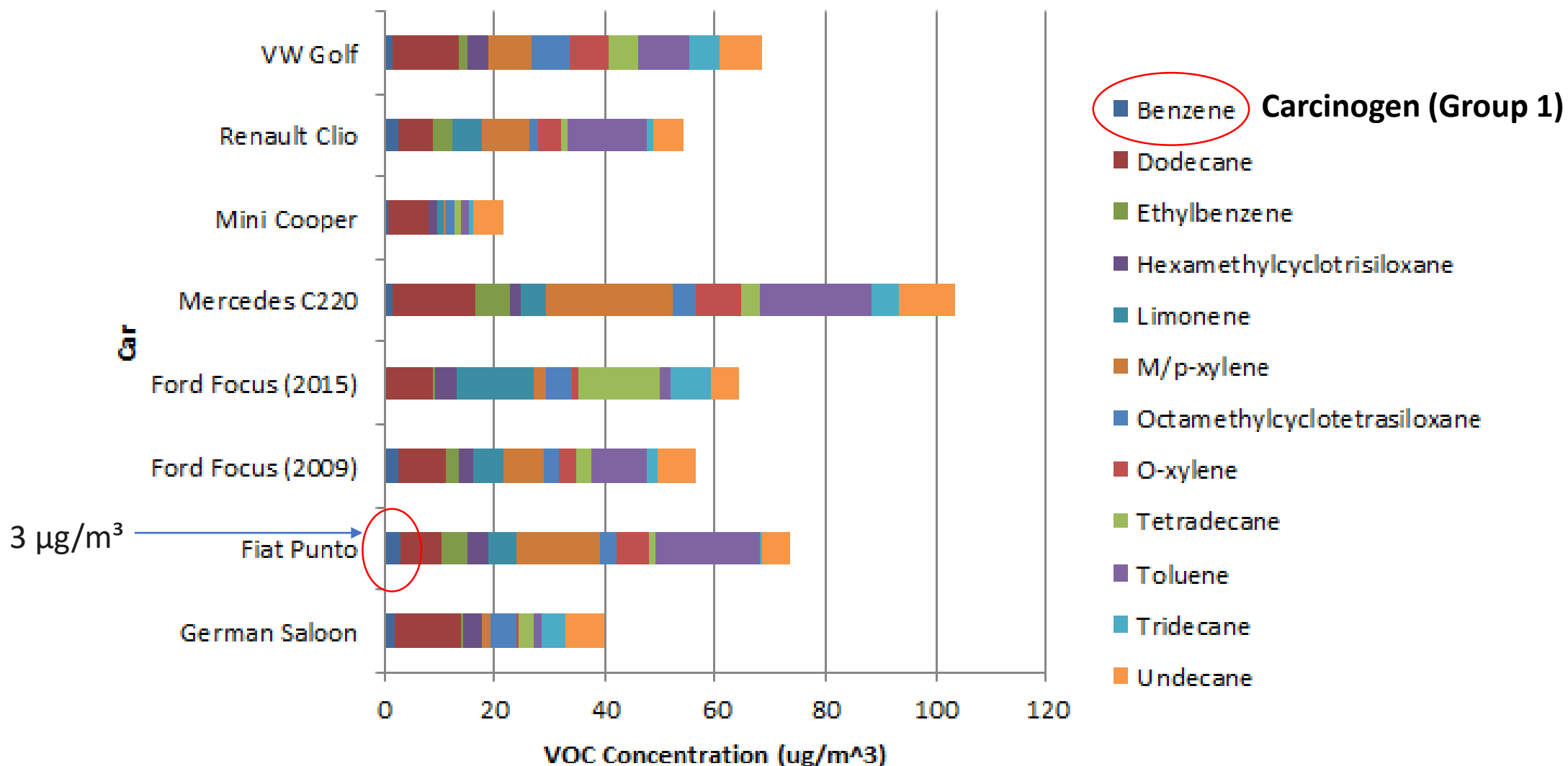


Health Effects

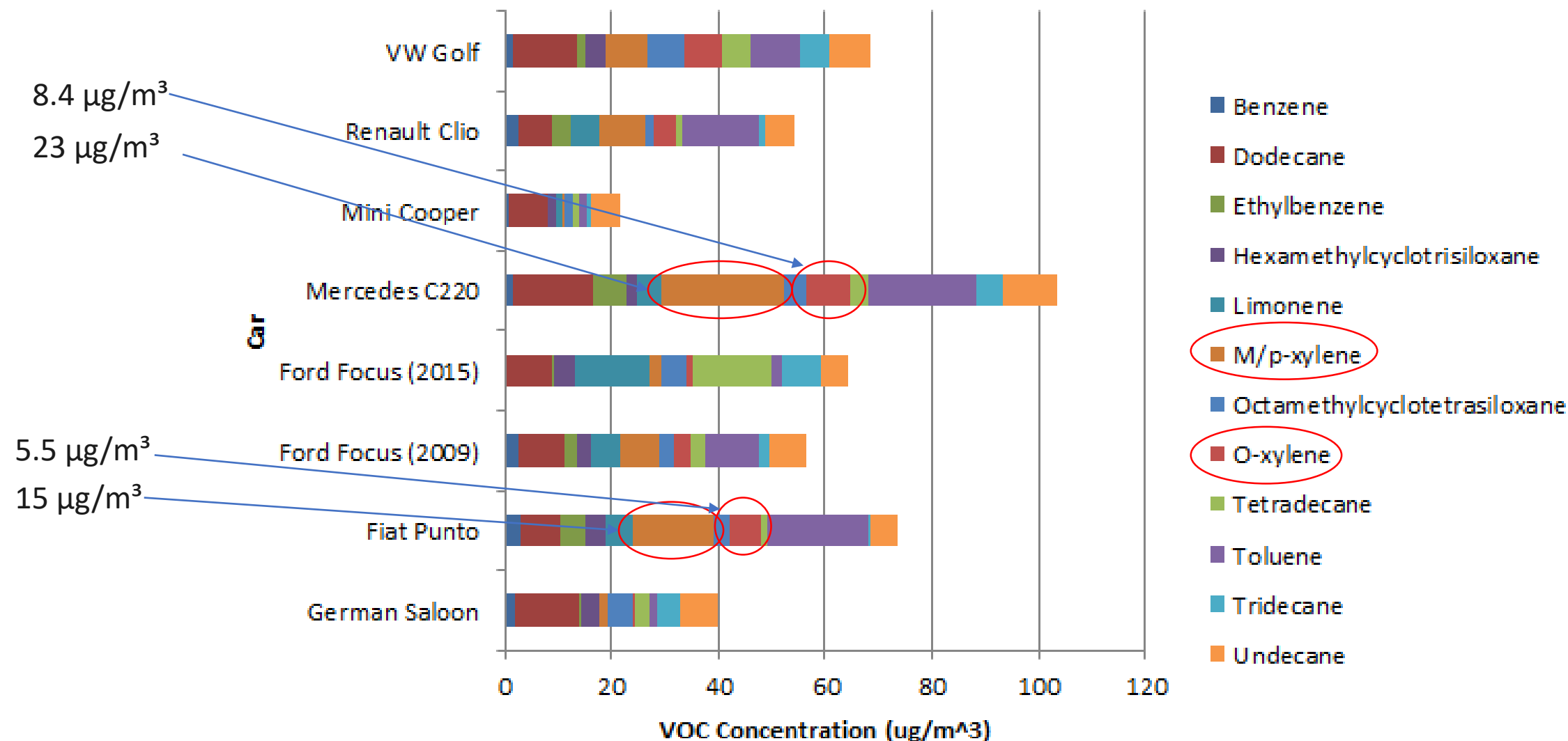
- <200 µg/m³ - No irritation or discomfort
- 200-3000 µg/m³ - Irritation and discomfort possible
- 3000-25000 µg/m³ - Discomfort expected and headache possible
- >25000 µg/m³ - toxic



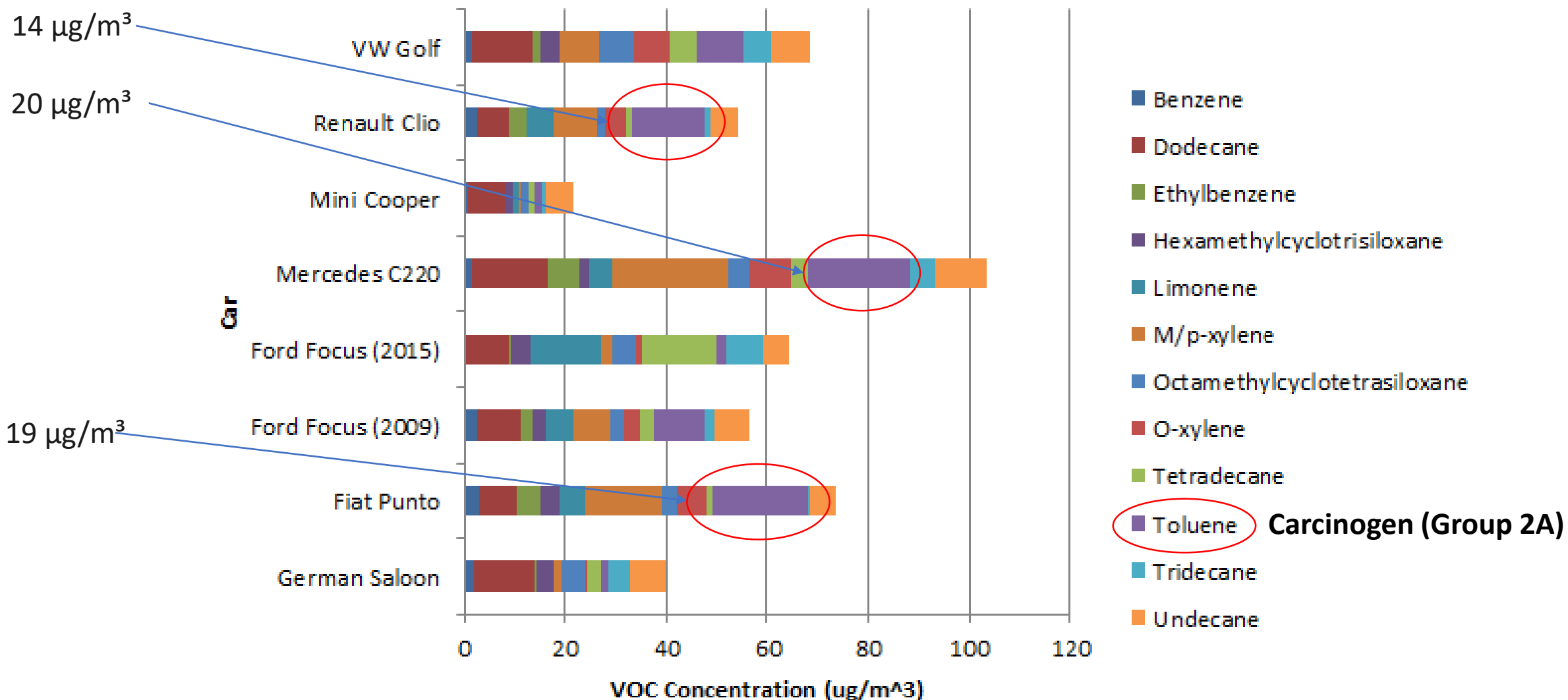
Comparisons II - Speciation



Comparisons II - Speciation



Comparisons II - Speciation



How do you communicate these results to the general public?

Vehicle manufacturers beginning to differentiate themselves based on VIAQ, we need more independent research to inform the consumer.



“You can literally survive a military grade bio attack by sitting in your car” - TESLA

**I'D TELL YOU A
CHEMISTRY JOKE BUT
I KNOW I WOULDN'T
GET A REACTION**



Complicated subject matter + general public aversion to analytical chemistry

Conclusions & Future Research

CONCLUSIONS

- TVOC quantities for German Saloon, Ford Focus (2009), Ford Focus (2015), Mercedes C220 & VW Golf are within range of irritation and discomfort. Although this was static and at a relatively low temperature, and inside so avoiding direct sunlight.
- More data needed!

FUTURE RESEARCH

- Deepen the static baseline testing to include warmer temperatures / direct sunlight
- Revisit Question 1: How much ambient air pollution is coming into the vehicle?
 - Real World Driving VOCs vs. Static VOCs
- Real-time TVOCs vs Speciation

Thanks!

Charlotte Farr, Lancaster University

Peter Allen, Marchwood Scientific Services

University of California Riverside



Marchwood Scientific Services



Any questions?

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