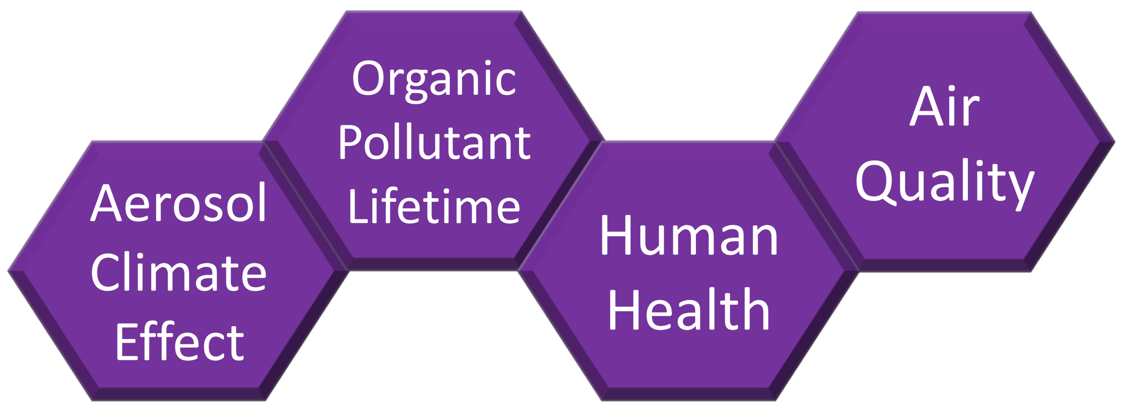
Characterisation of a New Oxidation Flow Reactor for Secondary Organic Aerosol Formation

Stephen Alexander Robertson
Supervisor: Prof. Gordon McFiggans
The University of Manchester, UK

MANCHESTER 1824
The University of Manchester

1. Background and Problem

Secondary Organic Aerosol (SOA) Related Issues



- Understanding SOA formation enables **regulation implementation and enforcement**; curtailing formation from primary sources.
- SOA formation typically studied using aerosol chambers and oxidation flow reactors.[1]
- Chambers use ambient or near-ambient conditions and offer atmospheric relevance with time resolved SOA formation mechanism data.[1]
- However, chambers often bespoke to each institute and their large size restricts portability.
- **Oxidation flow reactors** emerging as a complimentary technique using increased effective oxidant concentrations with **increased portability** and **low residence times.**[1]

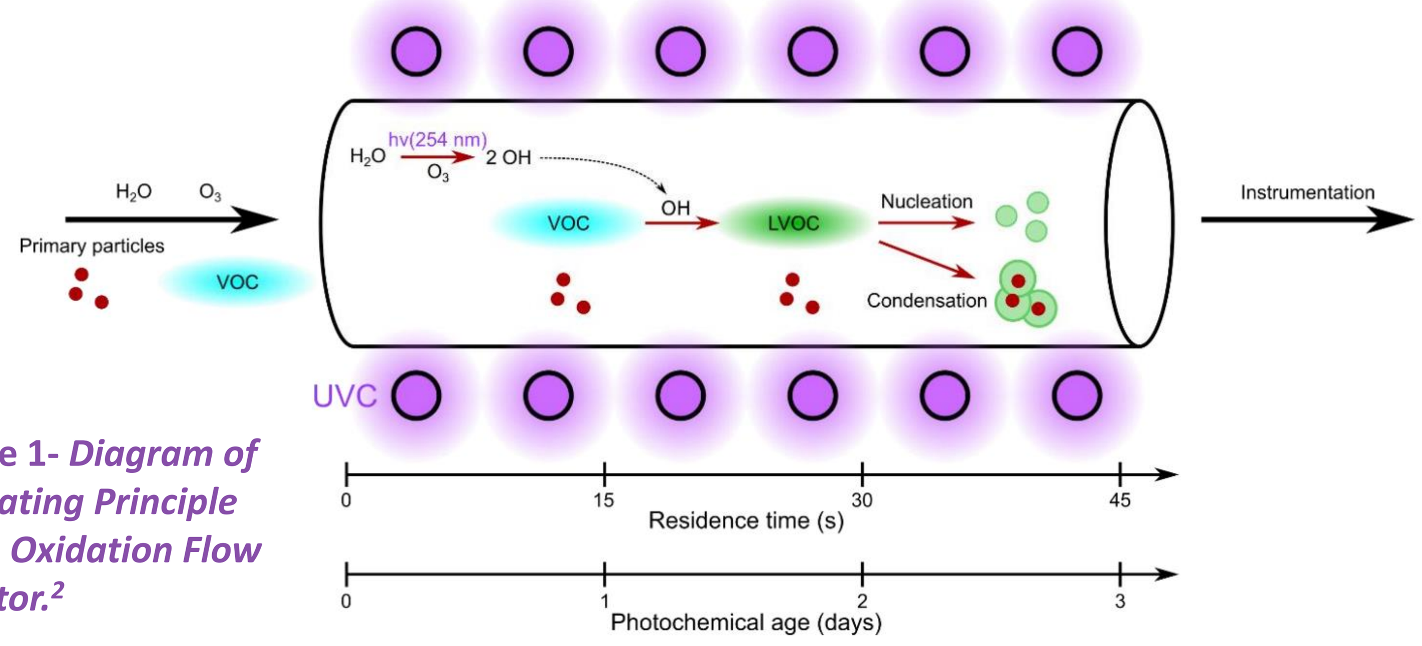


Figure 1- Diagram of Operating Principle of an Oxidation Flow Reactor.[2]

2. Hypothesis and Objectives

A **new commercial oxidation flow reactor** based on a model tested by the Tampere University of Technology, Finland, has been produced by Dekati.[3]

Figure 2- Image of Dekati Oxidation Flow Reactor Within Carry Case.[4]

- Offers **residence times** on the order of **seconds** and **increased portability** within a single carry case.[4]
- Marketed as a widely available, future standard, piece of equipment for SOA formation particularly for uses requiring high portability such as **transient vehicle studies.**[4]

Project aims:

1. Produce **best practice guidance** covering control parameters such as flow rate or illuminated UV lamp configuration.
2. Record effects on **chemical composition**, **mass yield**, and **number** and **size distributions** of produced SOA as a result of these changing parameters.
3. **Compare alternative methods** of SOA formation such as the Manchester Aerosol Chamber to assess atmospheric relevance and output differences.
4. Apply all of the above to simple “benchmark” **single VOC systems and more complex “reference” sources** such as wood burners or engine emissions.

3. Methodology

- Project is split into the study of simple “benchmark” systems and, more complex, “reference” sources.
- **Each system** studied will be **repeated** with **alternative SOA formation methods** such as the Manchester Aerosol Chamber.[5]

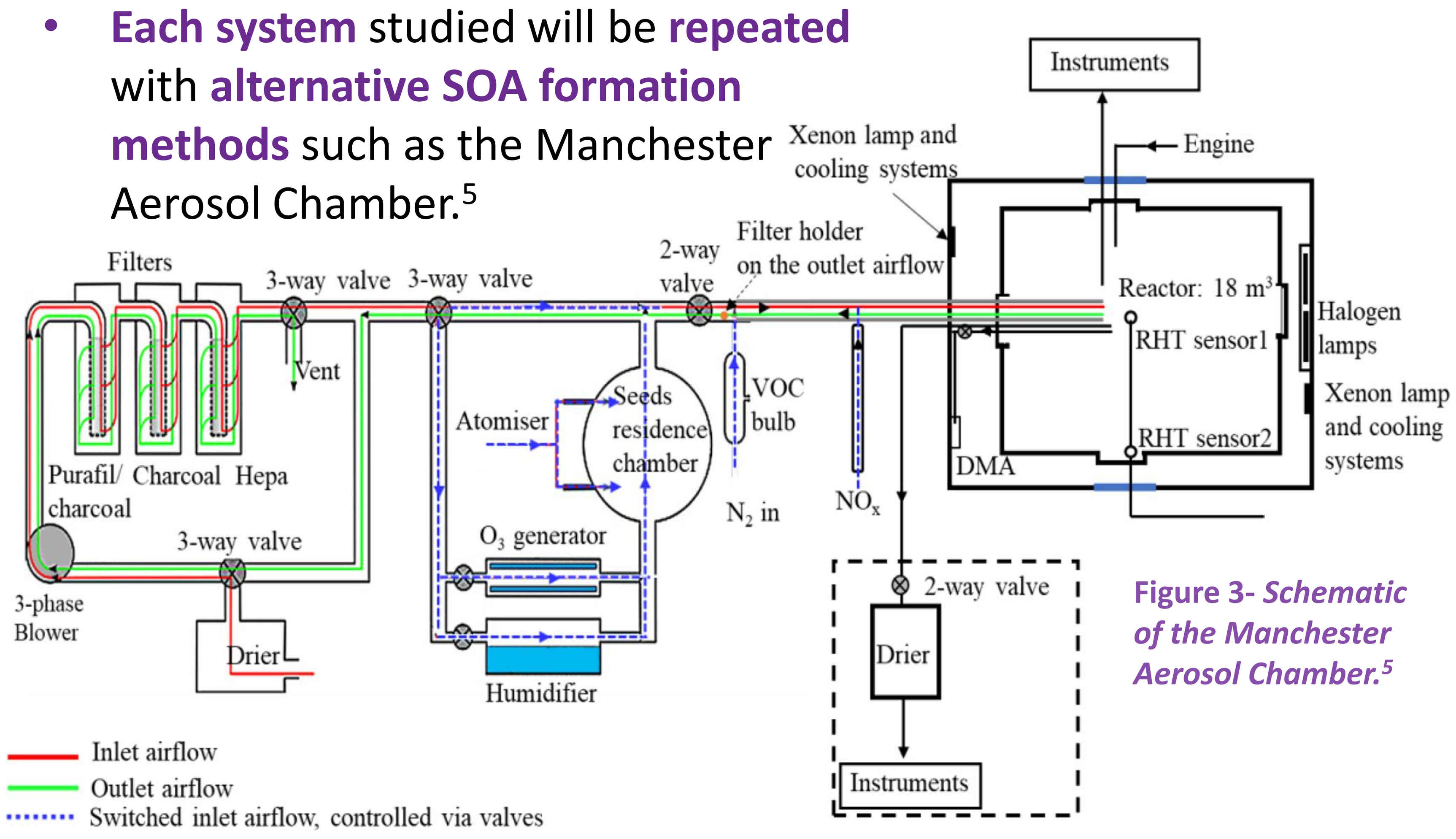


Figure 3- Schematic of the Manchester Aerosol Chamber.[5]

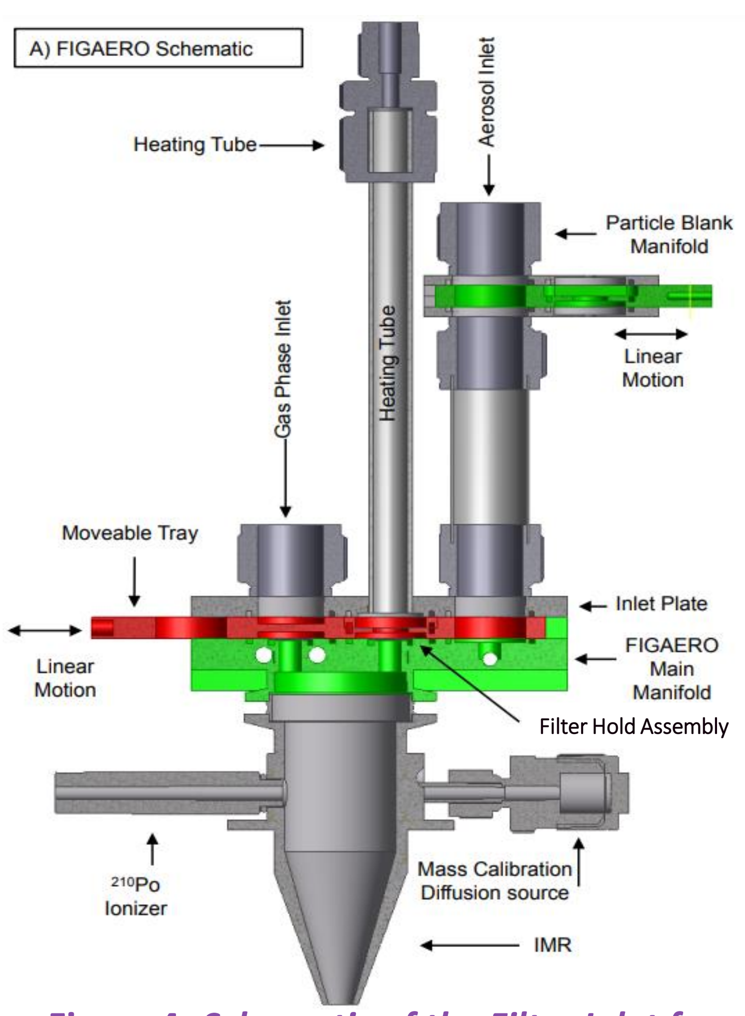


Figure 4- Schematic of the Filter Inlet for Gases and Aerosols (FIGAERO).[6]

- Data collection will use **chemical ionisation mass spectrometry** with **FIGAERO** inlet for chemical composition and volatility sets,[6] and a **TSI SMPS** and **Cambustion DMS500** for aerosol counting and size distributions.
- Gas phase oxidant behaviour will be monitored using skills acquired through a three month project at Leeds.
- Complimentary data may be acquired from other projects run within the Centre for Atmospheric Science, Manchester.

4. Implications and Challenges

- The Dekati oxidation flow reactor is entangled in a number of **socio-economic** and **environmental issues.**
- Usage in emission standard enforcement may generate new regulations or uncover social and economic imbalance with regards to SOA exposure.

Figure 5- Image of a Vehicle Emissions Test.[7]

- Adoption of the same reliable, relevant, and readily available oxidation flow reactor across institutions and organisations facilitates the study of SOA.
- Regularly reviewing developments in SOA targeted legislation and SOA research more generally will align this project with the needs of the field.

Project challenges may include:

- The **availability** and **consistency** of complex emission sources preventing rigorous comparison.
- **Inconsistent** or **complex variation** in properties of produced SOA requiring deeper investigation than planned.

Regular review of project progress and scope, and a **gradual increase in complexity** of studied systems will mitigate these challenges.

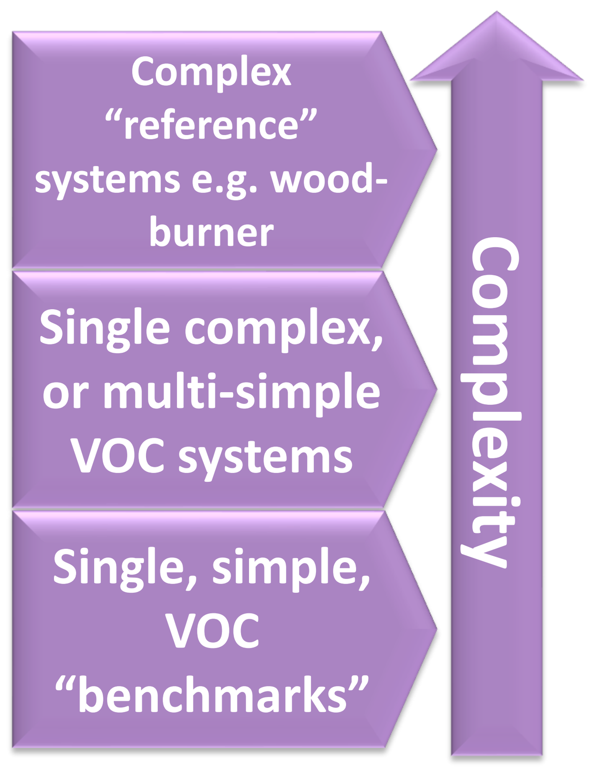


Figure 6- Example Path of Increasing Complexity

5. References

1. Peng, Z., et al., *Chem. Soc. Reviews*, 2022. 49 (9), 2570-2616.
2. Dekati Ltd., DOFR™ User Manual 1.0, 2022.
3. Simonen, P., et al., *Atmos. Meas. Tech.* 2017, 10 (4), 1519-1537.
4. Dekati Ltd., Dekati® Oxidation Flow Reactor DOFR™, Webpage. 2022.
5. Shao, Y., et al., *Atmos. Meas. Tech.* 2022, 15 (2), 539-559.
6. Lopez-Hilfiker, F., et al., *Atmos. Meas. Tech.* 2014, 7 (4), 983-1001.
7. Viinamäki, S., *Exhaust Gas Measurement*. 2017. Creative Commons.

UKRI Engineering and Physical Sciences Research Council
MANCHESTER 1824 The University of Manchester
DEKATI