Organic Aerosol Fractionation Using Subcritical Water

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What is subcritical water?

- Subcritical water can be defined as hot water under sufficient pressure to maintain the liquid state. (hot water, superheated water)

Why subcritical water?

- The **polarity** can be controlled with change of temperature.
- As the polarity of water is controlled, **solubility** is controlled. The solubility of PAHs and pesticides increases by an order of magnitude with every 50 °C.
- Water is **not toxic**.

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Properties of Subcritical Water

	25°C	300°C
dielectric constant (ε)	80	20
polarity	high	low
similar organic solvents	none	methanol, acetonitrile
compounds extracted	high polarity (e.g. strong organic acids)	low polarity (e.g. PCBs, PAHs)

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Characterization of Organic Aerosols

Limitation of current methods

- Organic solvents employed extract non-polar or slightly polar organic compounds (20-50% of carbonaceous extracted).
- GC/MS analyses (not suitable for all compounds)

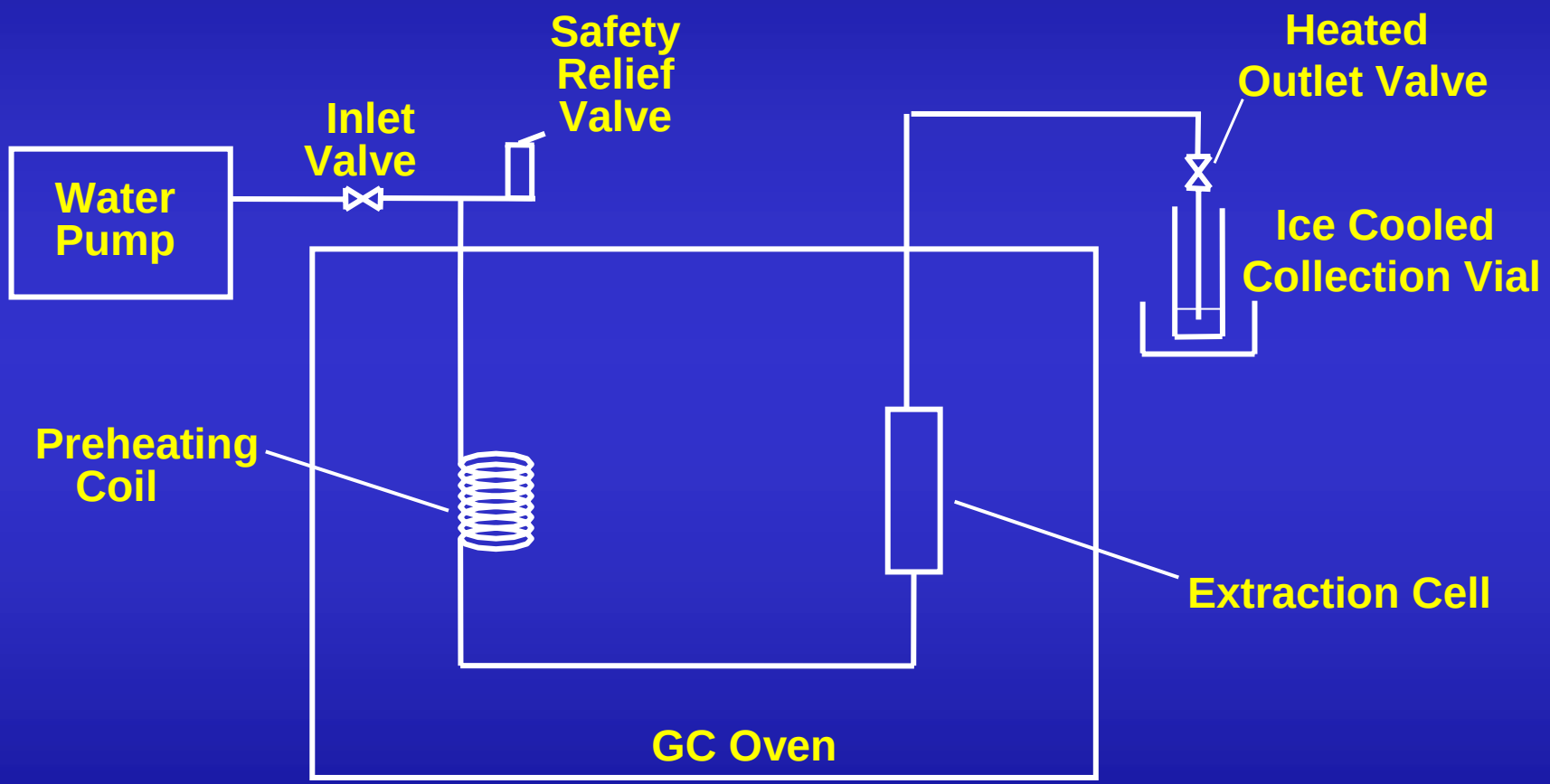
Our Approach

- Sequential fractionation with subcritical water
- Characterization using toxicity tests

Fractionations with subcritical water were performed with two common carbonaceous aerosols:

- **Wood smoke particulate (polar matrix)**
- **Diesel exhaust particulate (relatively nonpolar matrix)**

Subcritical Water Extraction Apparatus



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Toxicity tests

BACTERIAL

- Polytox: Rapid test for measuring the toxicity of wastewater based on the inhibitory effect on respiration rate of mixed bacterial cultures.

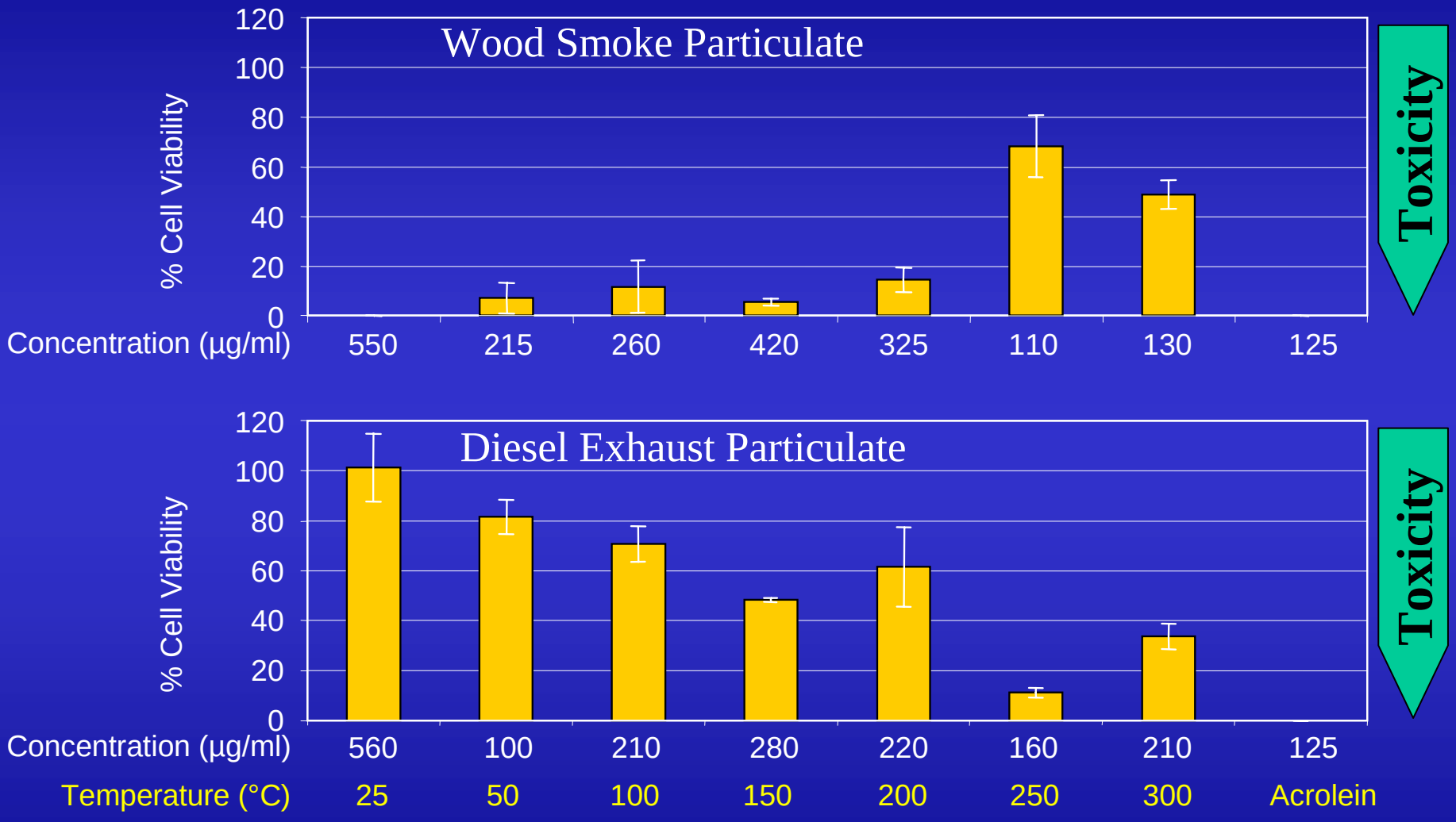
- SOS chromotest: Genotoxicity test based on DNA damage.

MAMMALIAN

- Cytotoxicity test: Based on the inhibited mammalian cells (COS) viability.

- Mitochondrial respiration

Cytotoxicity – Viability of Mammalian Cells



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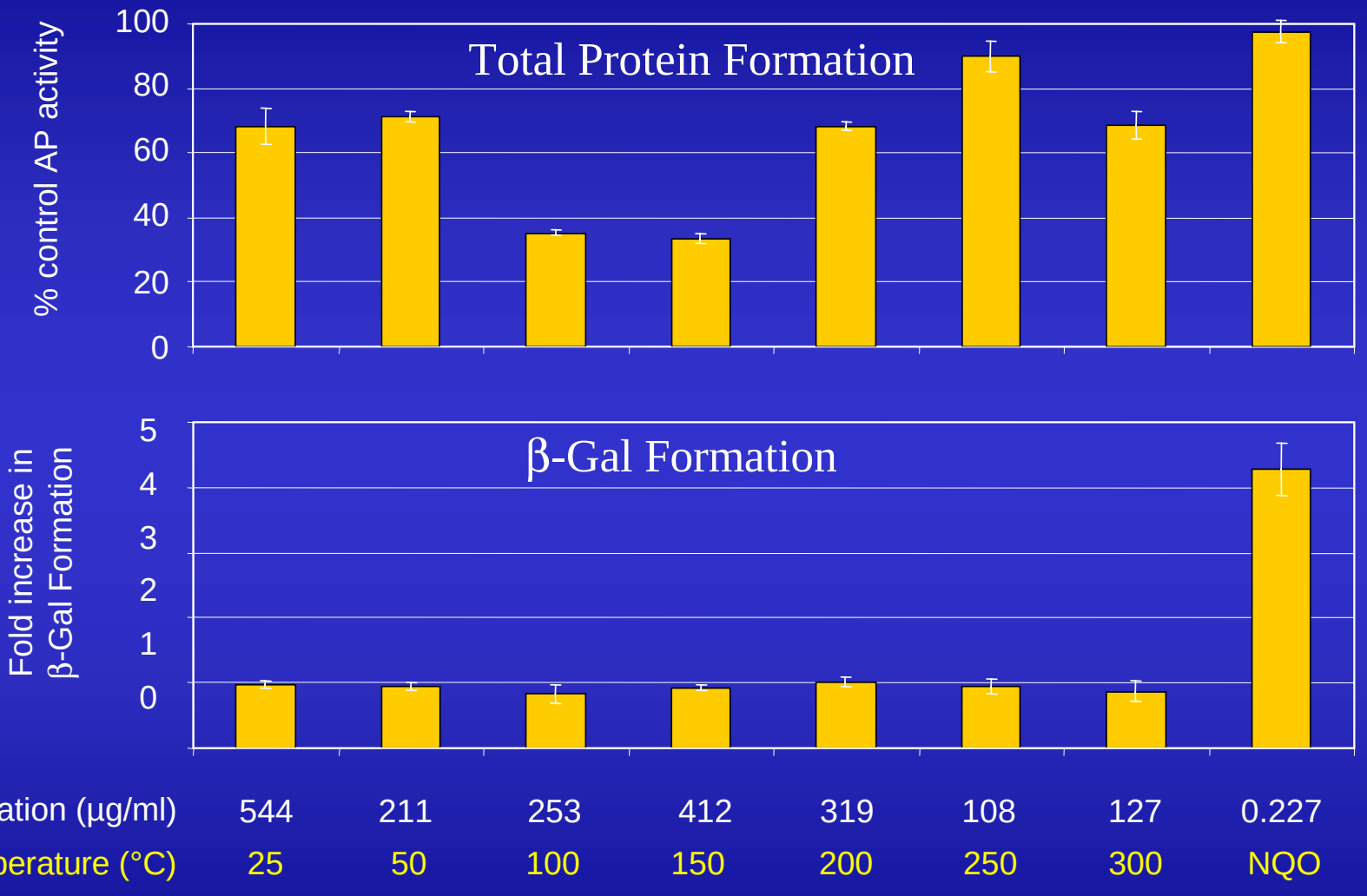
SOS Chromotest - Wood Smoke Particulate



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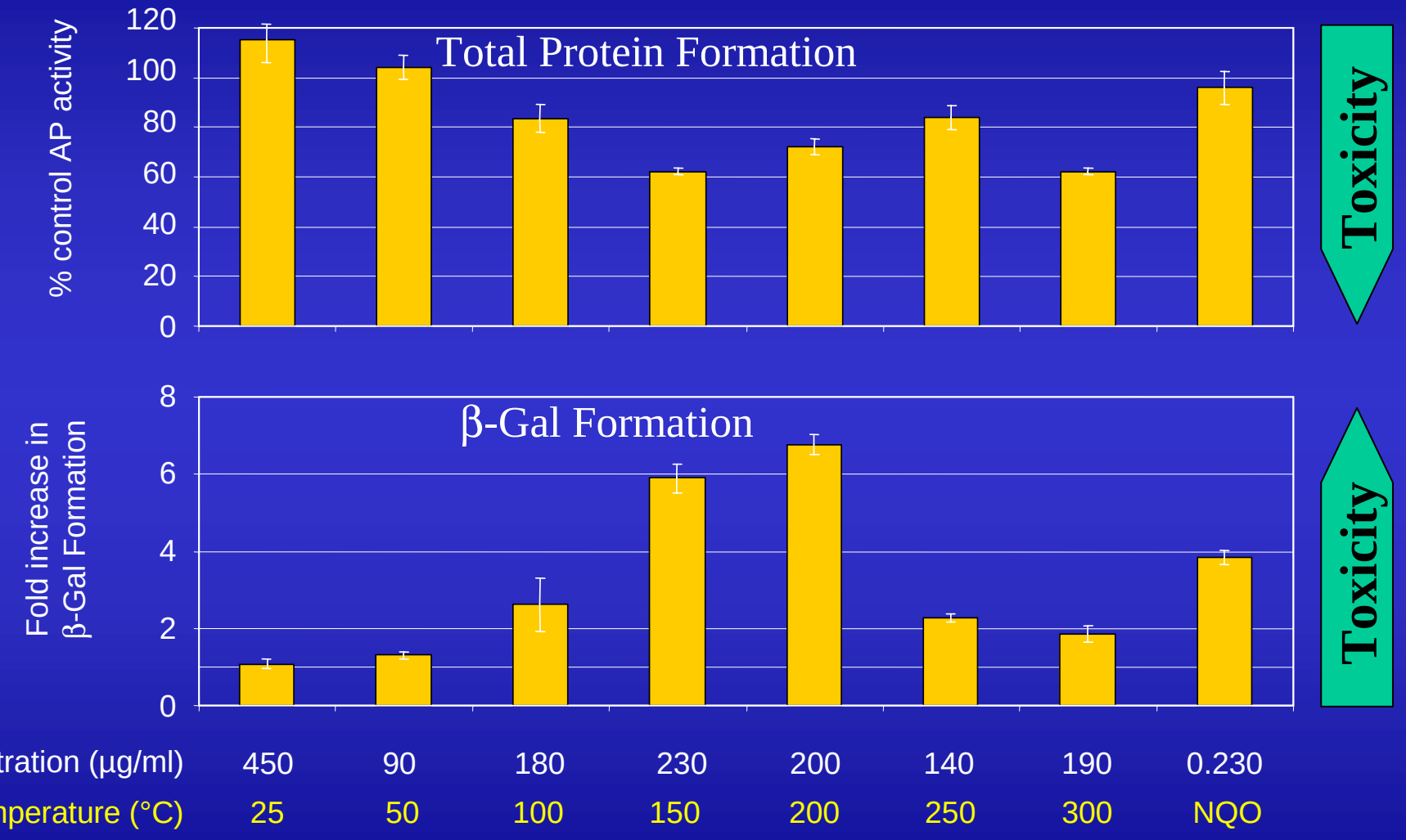
SOS Chromotest - Diesel Exhaust Particulate



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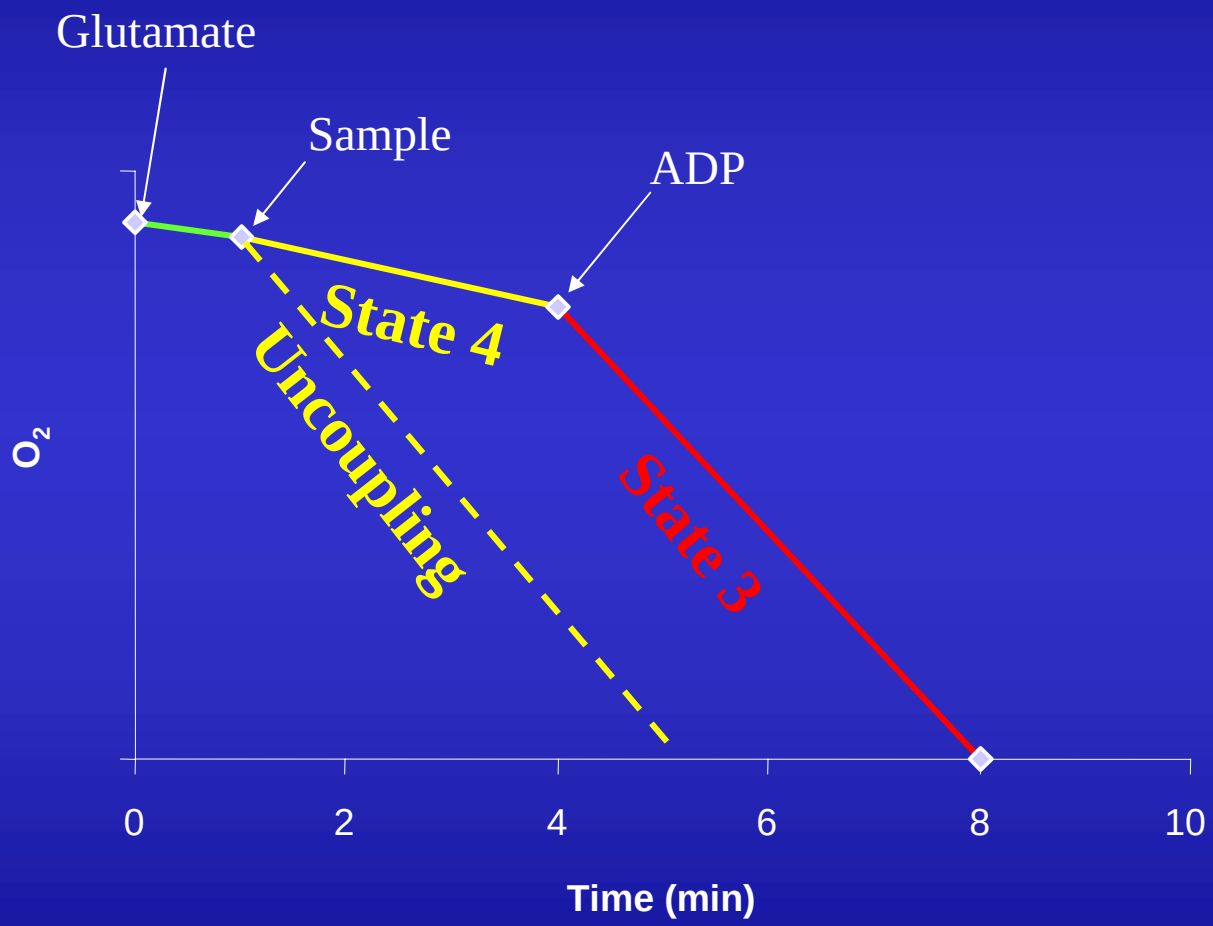
Mitochondrial Respiration



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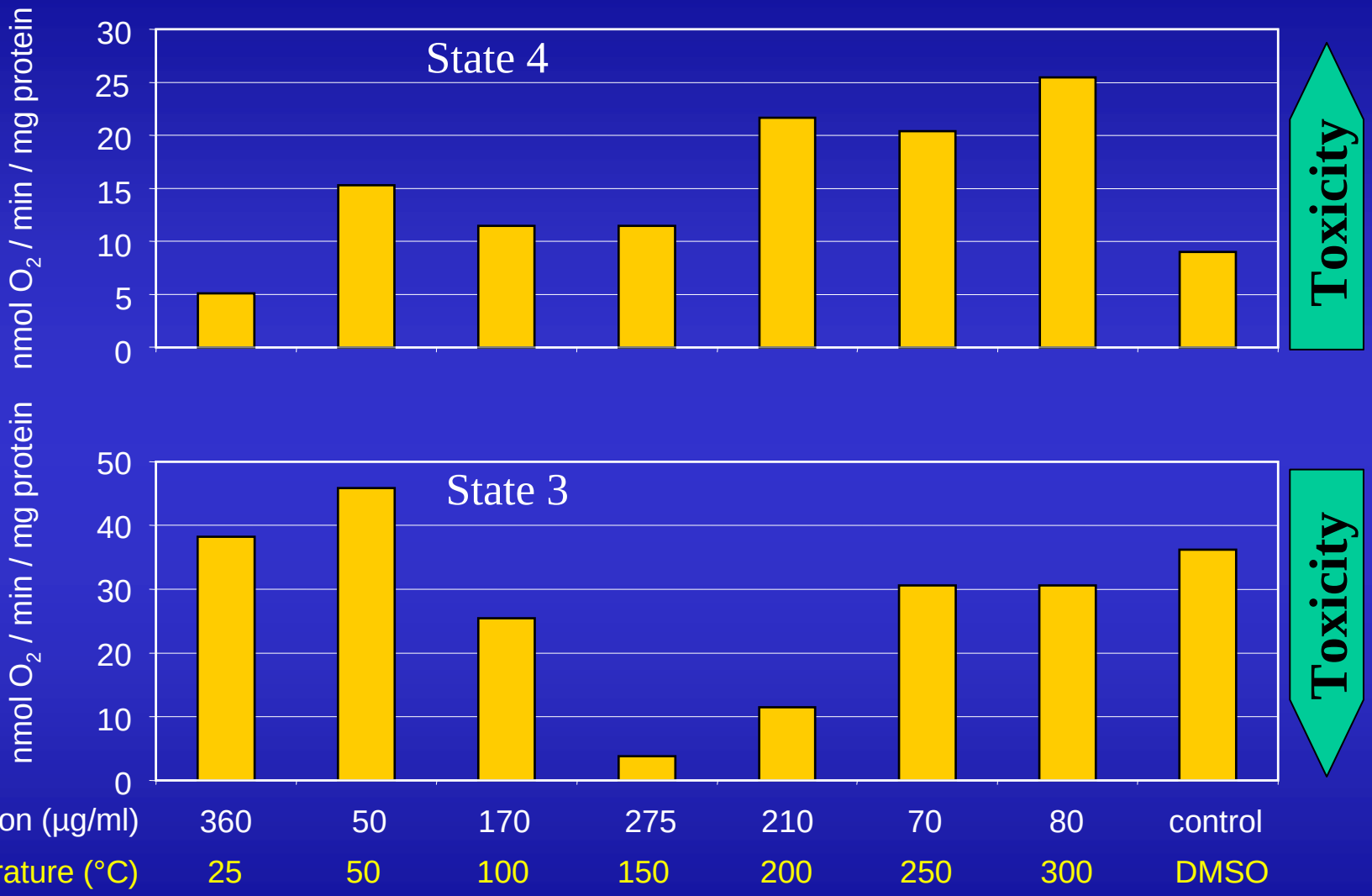
Mitochondrial Respiration – Wood Smoke Particulate



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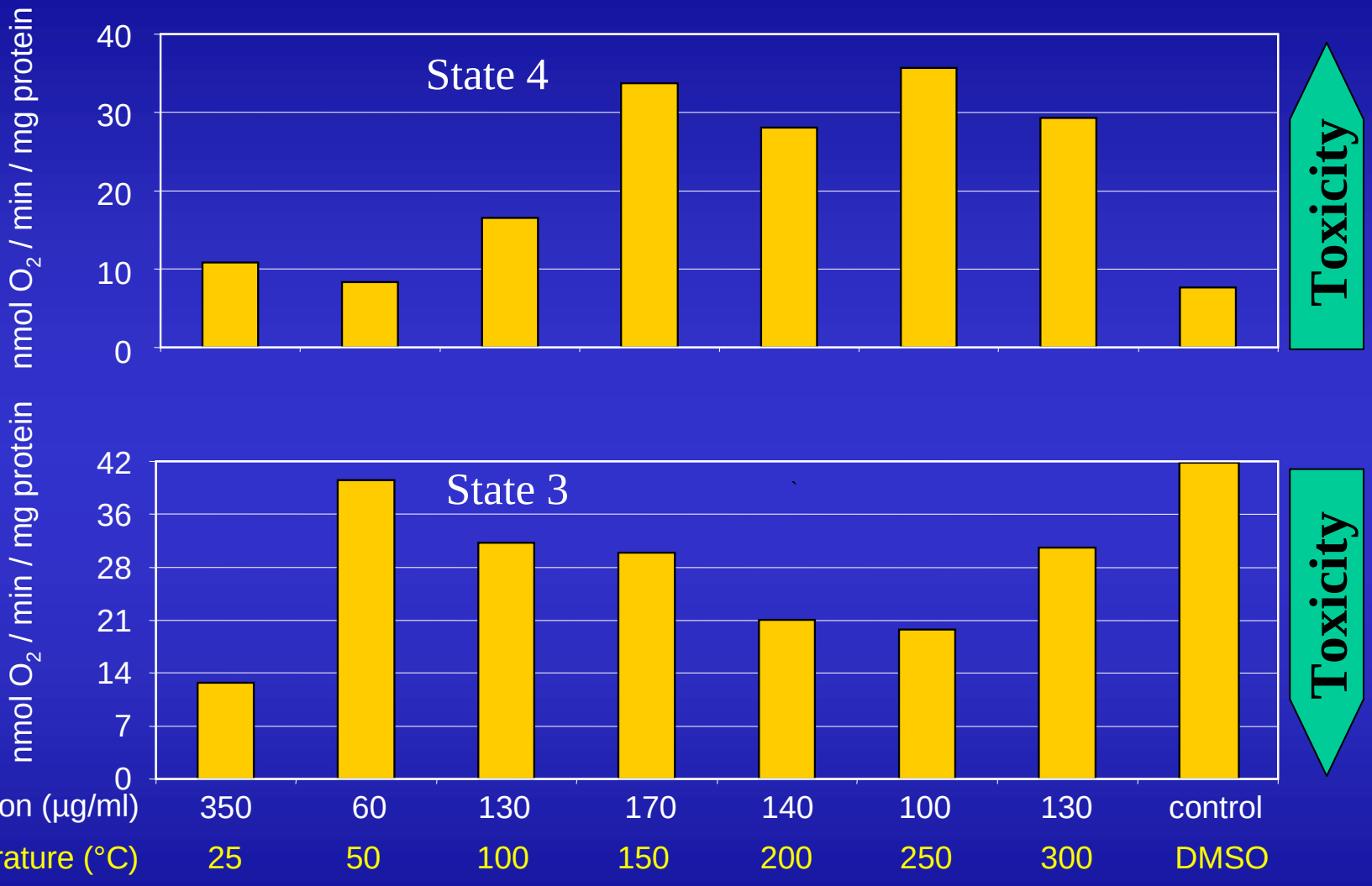
Mitochondrial Respiration – Diesel Exhaust Particulate



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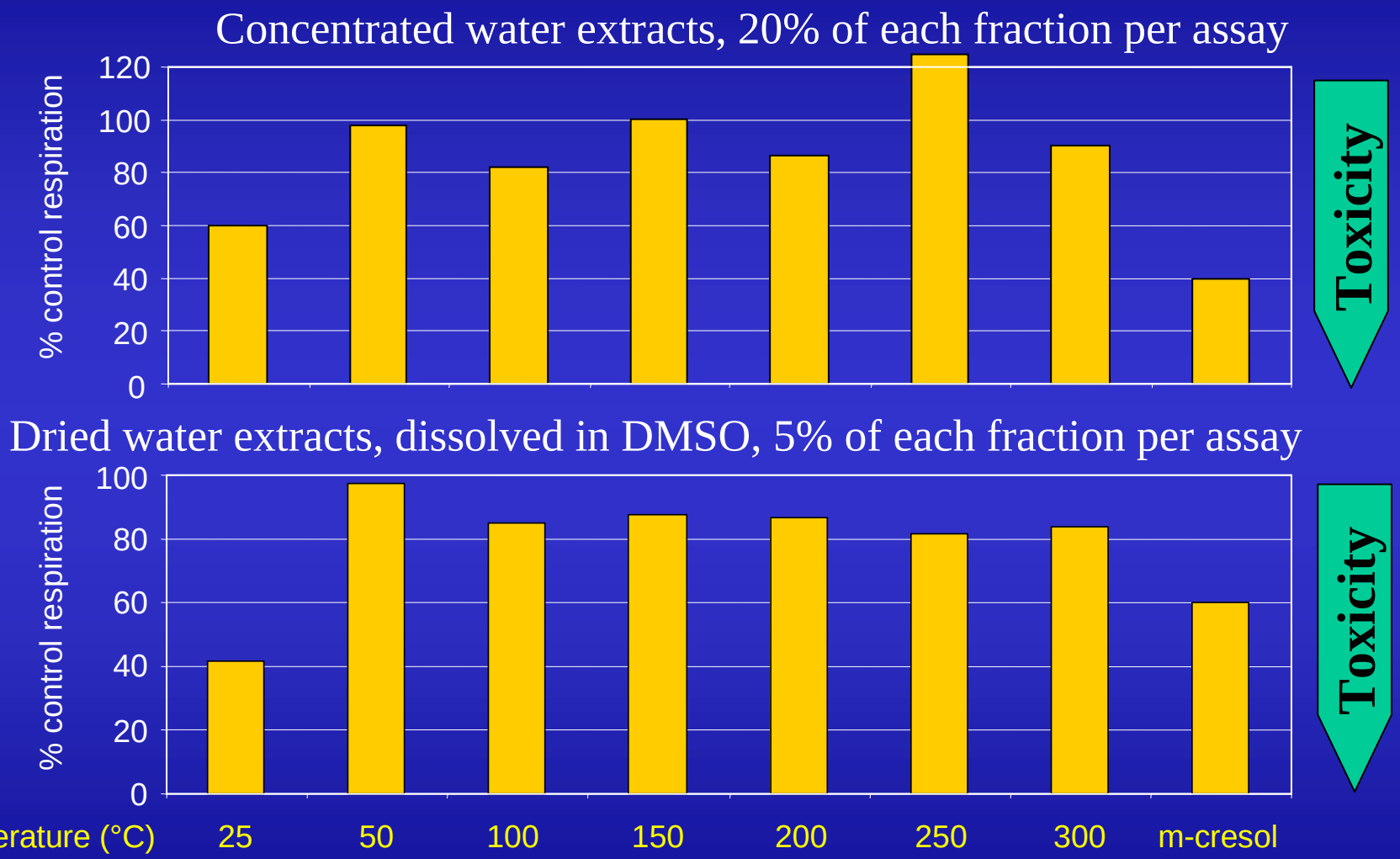
Bacterial Respiration (POLYTOX™) with Diesel Exhaust Particulate Water Extracts



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Fractionation of Aerosols with Subcritical Water

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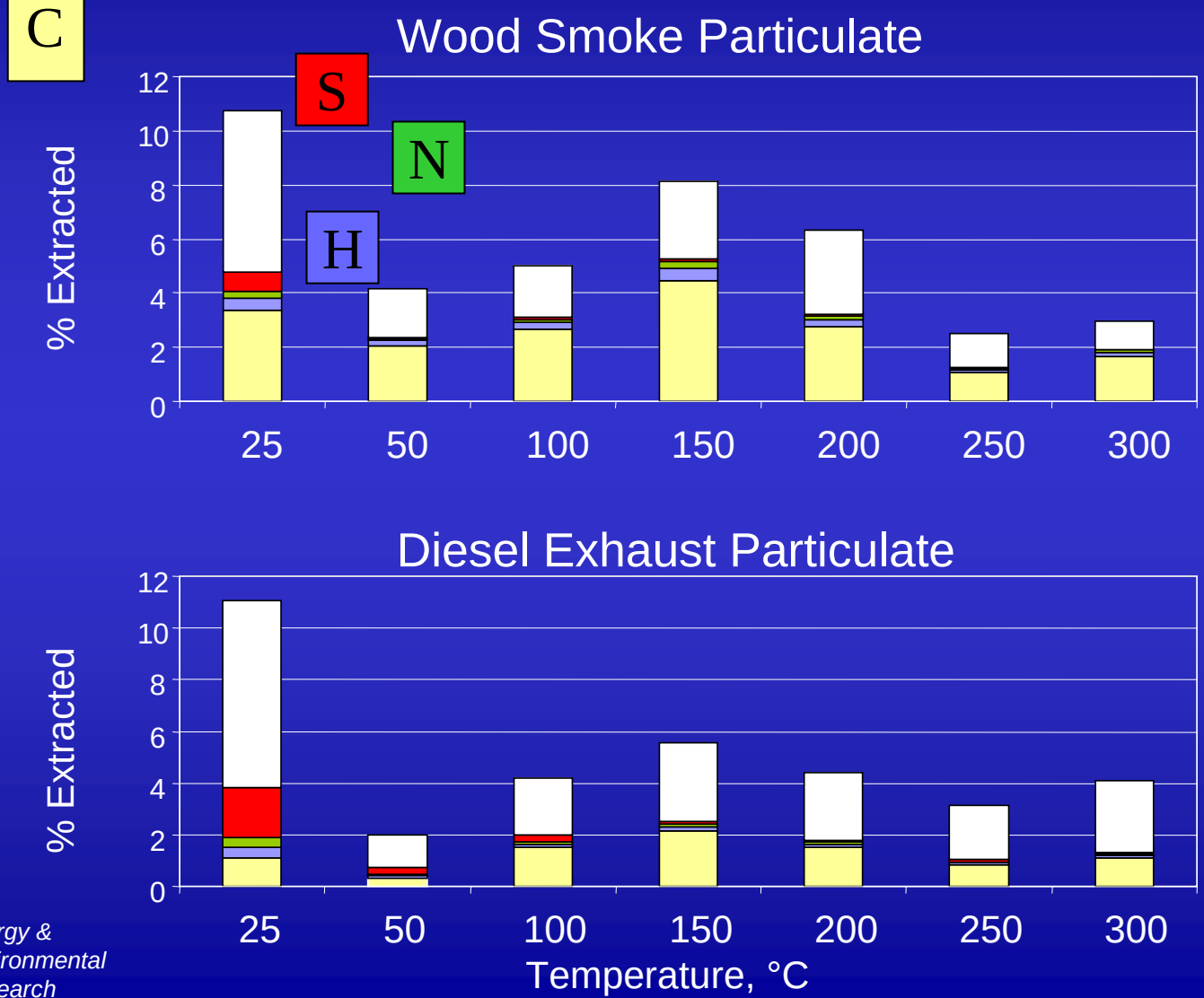

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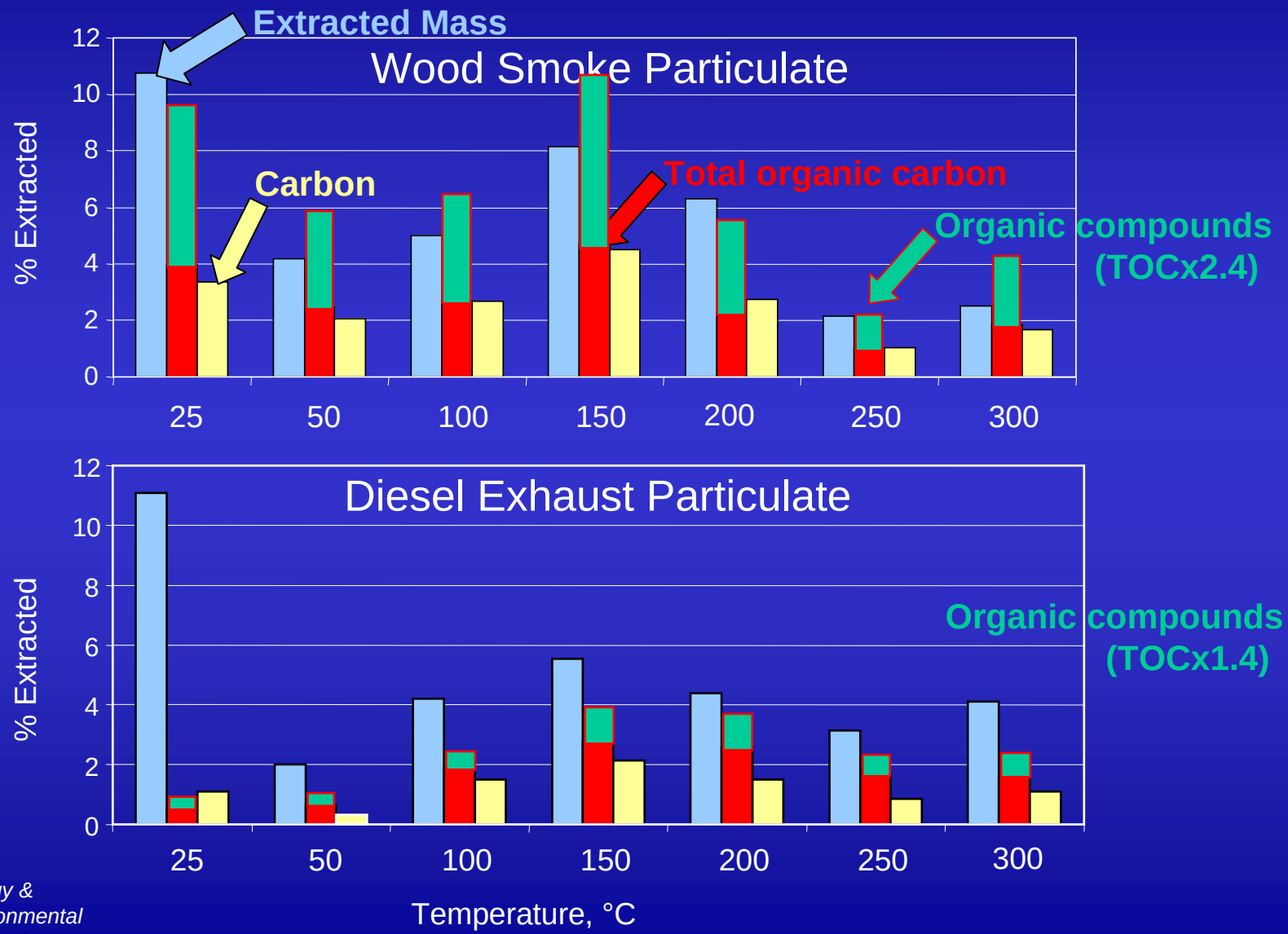
Determination of carbon and total organic carbon (TOC)



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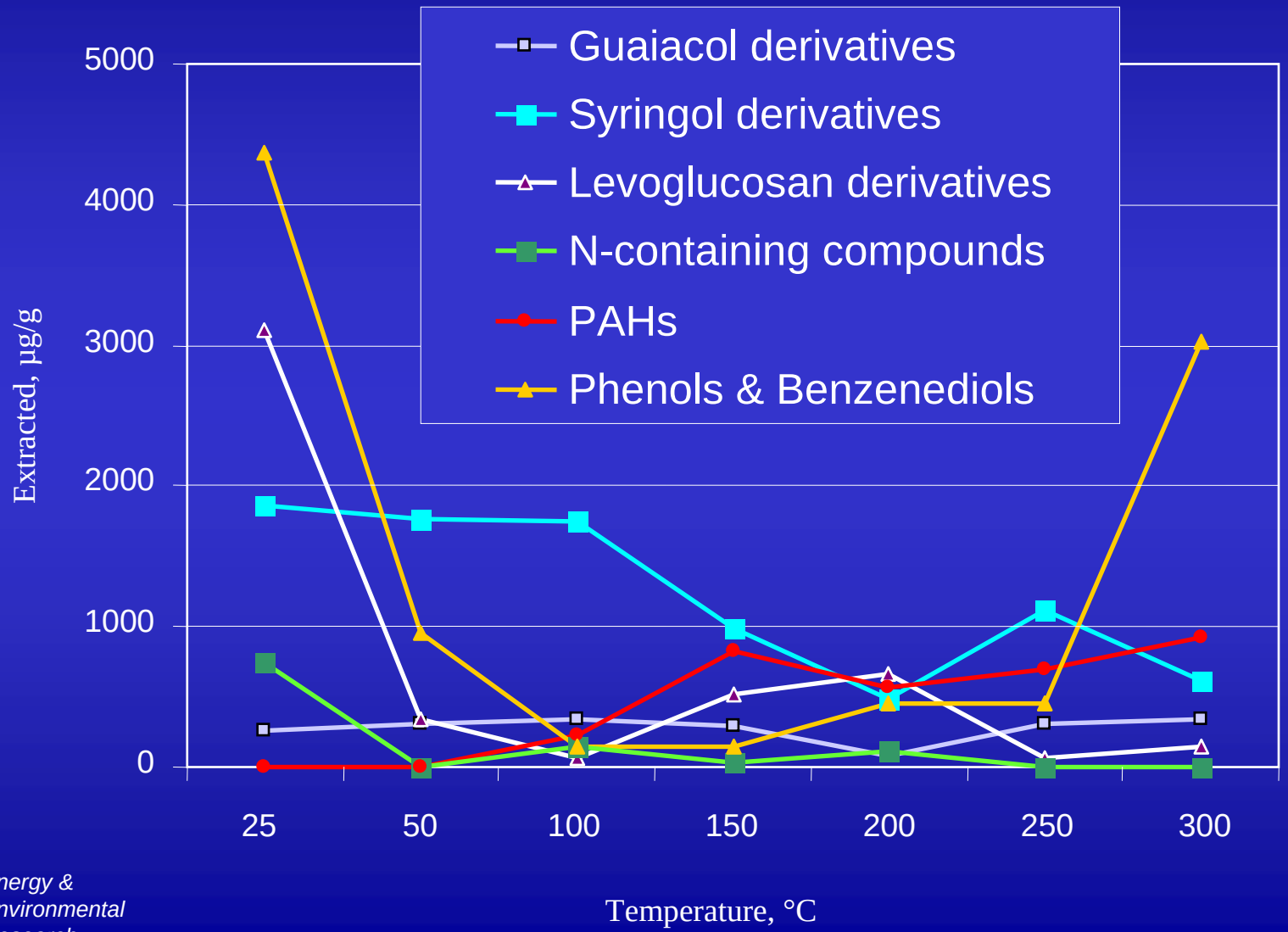
Distribution of Different Classes of Organics in Wood Smoke Particulate Extracts Collected at Different Temperatures



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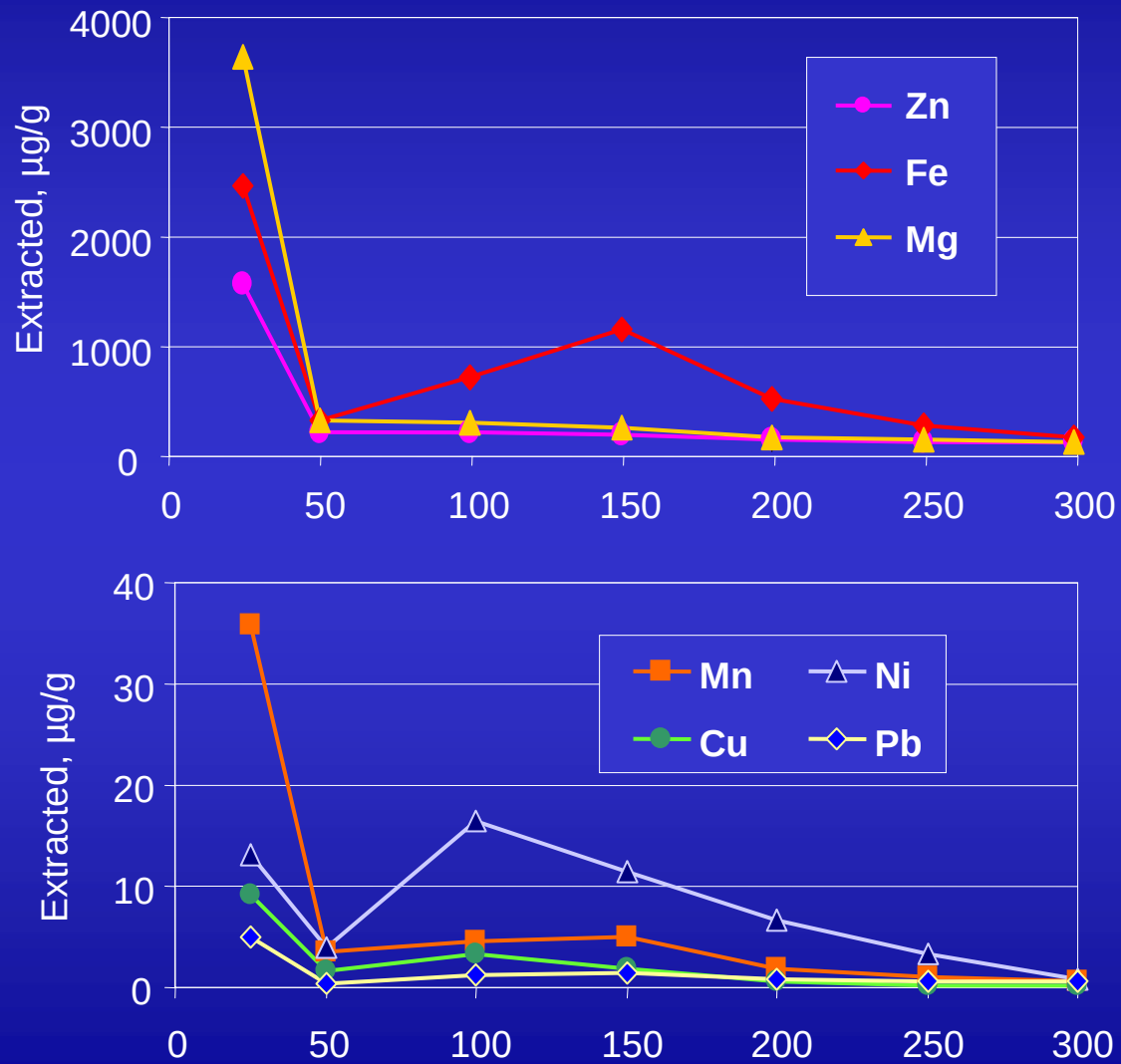
Metals Determined Using ICP/MS in Diesel Exhaust Particulate



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Conclusions

- Subcritical water can selectively extract organics.
- High toxicity was found in the polar fractions, fractions which are not expected to be extracted by organic solvents. Except Polytox™ all test exhibited high sensitivity.
- GC/MS characterization of wood smoke particulate showed phenols, benzenediols and levoglucosan extracted preferentially in lower temperature fractions.
- Higher content of sulfur, magnesium, iron and zinc was found in the lower-temperature fraction of diesel exhaust.
- The results indicate that standard methods employing organic solvents neglect characterizing the polar fractions of aerosol particulate which are important from a toxicological point of view.