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# Smart Sensing of Alcohol Vapours with a Molybdenum Coordination Complex

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## INTRODUCTION & AIM

The selective and sensitive detection of volatile alcohol such as methanol or ethanol at ambient conditions is of great importance in environmental monitoring,[1] industrial process control,[2] and public health[3] due to their widespread use and potential toxicity. Transition metal coordination complexes, particularly those of molybdenum, have shown great semiconductor properties,[4] making them ideal candidates for molecular recognition and sensor applications. Their ability to engage in specific interactions with hydroxyl-containing analytes,[5] combined with tuneable electronic properties, allows for tailored sensor design with high selectivity.

In this study, we report the synthesis and characterization of a novel molybdenum coordination complex. The sensor's response to MeOH/EtOH vapours was systematically investigated by solid-state impedance spectroscopy (SS-IS) at room temperature (RT), while electrical properties were studied in wide temperature range. The complex exhibited reversible modulation of conductivity at RT, indicating efficient and selective alcohol detection.

## METHOD

The ligand was synthesized through a condensation reaction between oxalyldihydrazide and 2-hydroxy-3-methoxybenzaldehyde, yielding a Schiff base. This ligand was then coordinated to $\{MoO_2\}^{2+}$ core in MeOH under reflux conditions to form a dinuclear molybdenum(VI) complex, formulated as $[Mo_2O_4(L)(MeOH)_2]\cdot 2H_2O$. The resulting complex was isolated as an orange powder and characterized by spectroscopic methods.

To investigate its potential as a chemical sensor, particularly for alcohol vapours, the complex was exposed to MeOH and EtOH vapours, and the changes in its conductivity were monitored using SS-IS. The electrical properties of the complex were studied via SS-IS over wide range of frequencies (0.01 Hz – 1 MHz) and temperatures (40 – 200 °C).

This approach allowed for the assessment of the complex's vapour sensing capabilities, revealing characteristic response upon exposure to MeOH vapours.

## REFERENCES

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## ACKNOWLEDGEMENTS

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## RESULTS & DISCUSSION

**Table 1.** Conductivity, response ($t_{res}$) and recovery ($t_{rec}$) time after exposure of the dinuclear complex $[Mo_2O_4(L)(MeOH)_2]\cdot 2H_2O$ to methanol vapours.

| Solvent vapours | Number of cycles | Conductivity / $(\Omega\ cm)^{-1}$ | $t_{res}$ / s | $t_{rec}$ / s |
|---|---|---|---|---|
| Methanol | 10 | $5.20 \times 10^{-8}$ | 50 | 540 |

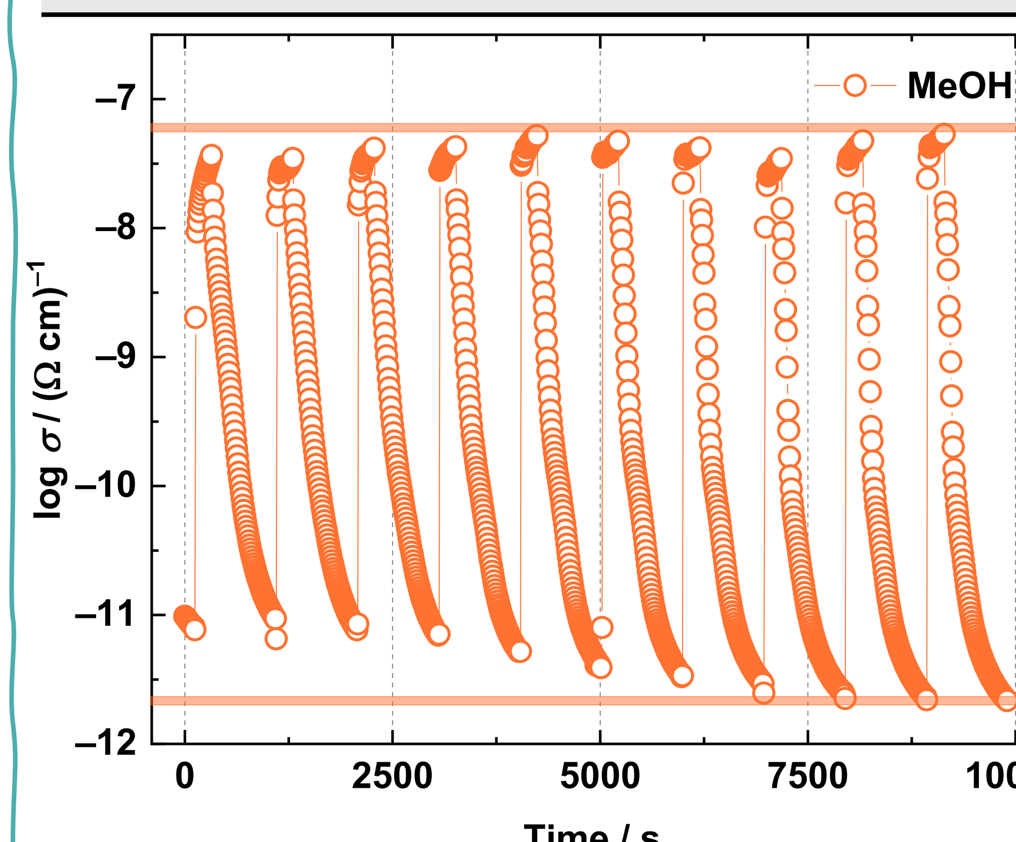


**Figure 1.** Conductivity after exposure of complex $[Mo_2O_4(L)(MeOH)_2]\cdot 2H_2O$ to MeOH vapours over 10 cycles. After initial exposure, the sample was left in air to relax before being re-exposed. Measurement was carried out at 1 Hz.

Analog measurements to EtOH vapour were performed over five cycles, with a response time of 1250 s and recovery time at 1060 s.

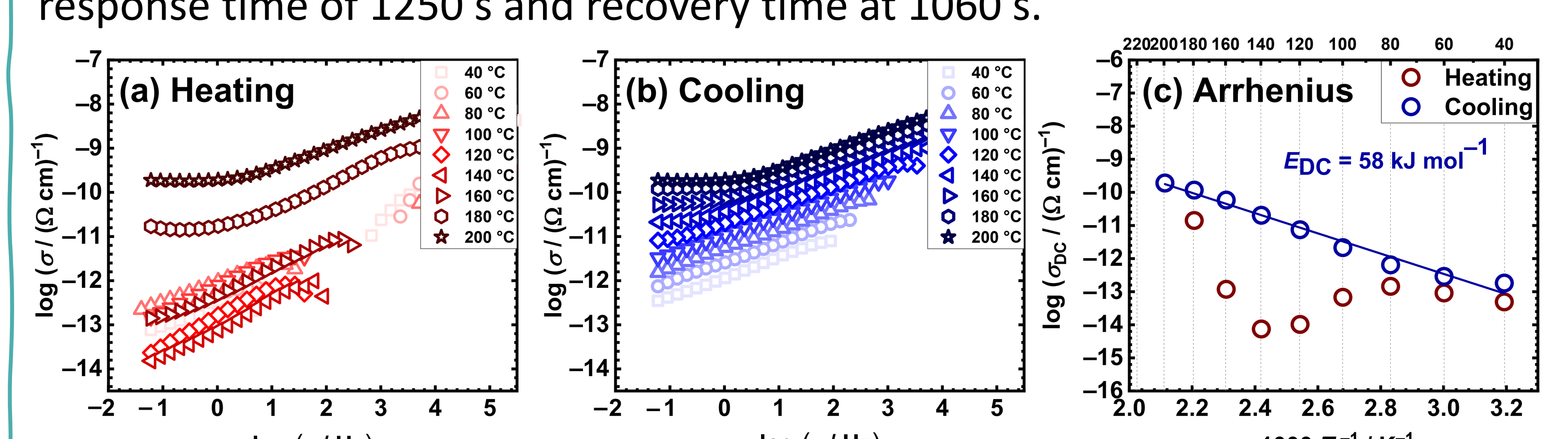


**Figure 2.** Conductivity spectra for $[Mo_2O_4(L)(MeOH)_2]\cdot 2H_2O$ in heating (a) and cooling (b) runs, and (c) temperature dependence of DC conductivity ($\log(\sigma_{DC})$ vs. $1000/T$) for both runs (red circle—heating, blue circle—cooling).

## CONCLUSION

The dinuclear molybdenum(VI) complex $[Mo_2O_4(L)(MeOH)_2]\cdot 2H_2O$ was successfully synthesized and characterized.

**Selective methanol sensing:**

The complex demonstrated selective vapour sensing properties towards MeOH. Electrical conductivity increased significantly to $5.2 \times 10^{-8}\ (\Omega\ cm)^{-1}$ upon exposure to MeOH. Response and recovery times were fast, at 50 s and 540 s, respectively, representing great performance at RT. Reproducibility tests over 10 sensing cycles confirmed the material's stability and suitability for practical sensor applications.

**Temperature-dependent conductivity**:

The complex exhibited a temperature-dependent increase in electrical conductivity, consistent with semiconducting behaviour. At 200 °C, the conductivity was measured at $1.91 \times 10^{-10}\ (\Omega\ cm)^{-1}$. Both the conductivity value and the activation energy of 58 kJ mol$^{-1}$ are in close agreement with those reported for related molybdenum-based systems.[4,6]

**Dual functionality:**

This research highlights the dual functionality of the synthesized molybdenum complex, showing promise for both sensor and electronic applications.