

Negative ion mobility and ion-molecule reactions in O₂ with a trace amount of moisture

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The mobility of negative ions was measured in O₂ while varying the H₂O concentration using a high-pressure ion drift tube with a point-plane gap acts as a negative ion detector. The H₂O concentration was monitored during the mobility measurement with a trace moisture analyser. Decreasing mobility were observed with increasing the H₂O concentration between 15 to 17000 ppb as 2.39, 2.31, 2.21 and 2.15 cm²/V·s. The mobility 2.39 cm²/V·s is considered as O₄⁻, and then O₄⁻ was converted to O₂⁻·(H₂O), O₂⁻·(H₂O)₂ and O₂⁻·(H₂O)₃ by ion-molecule reactions. Thus, decreasing mobility could be interpreted as the variations of ion species by ion-molecule reactions which were reproduced by solving the continue equations using the modified rate coefficients.

1. Introduction

We have been measured negative ion mobility in O₂ at high-pressures using a high-pressure ion drift tube with a point-plate gap acts as an ion detector [1, 2]. At such high-pressures, the negative ion mobility is strongly affected by impurities although the concentrations of impurities are lower than a few ppm. In this paper, we describe the results of ion mobility measurement and ion-molecule reactions in O₂ with a trace amount of moisture.

2. Experimental set up

The measurement method used for negative ion mobility had already been described in previous papers [1, 2]. During the measurements, H₂O concentrations were monitored by a trace moisture analyzer (HALO-H₂O: Tiger Optics) whose principle is based on a cavity ring-down spectroscopy [3] using a light of which wave length is 1392.53 nm.

3. Results and discussions

Figure 1 shows the obtained mobilities and the corresponding relative intensities of ions calculated using the rate coefficients in zero dimension. The mobility 2.39 cm²/V·s was observed in the range of H₂O concentration between 15 to 450 ppb which is considered as O₄⁻. After that, the mobility is decreased to 2.31, 2.21 cm²/V·s considered as O₂⁻·(H₂O) and O₂⁻·(H₂O)₂ in the H₂O concentration 450 to 4600, 4600 to 17000 ppb, respectively. The mobility 2.15 cm²/V·s considered as O₂⁻·(H₂O)₃ is also observed at the range of H₂O concentration between 12500 to 17000 ppb.

We considered the sequential progress of negative ions in O₂ with a little amount of moisture as shown in fig. 2. O₂⁻ having a mobility 2.17 cm²/V·s [4] was never observed in our experiment because measurements were carried out around atmospheric pressure. In fig. 1 (b), the rate coefficients k_1 , k_2 and k_3 reported by others [5-8] were used for the

calculation. In contrast, other rate coefficients k_4 , k_5 and k_6 were modified to fit in experiments because some of them were not sufficiently to convince us. The result is shown in fig.1 (b) as an example.

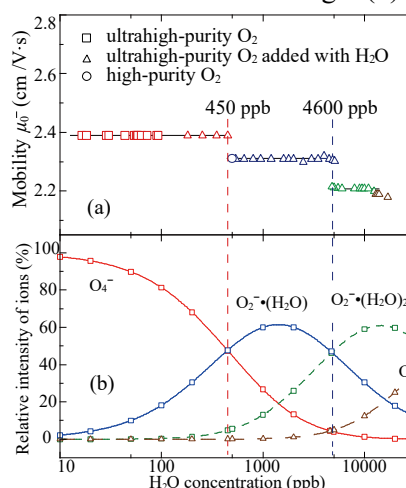


Fig. 1 Observed mobilities and their relative ion intensities against H₂O concentration.

Acknowledgement

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4. References

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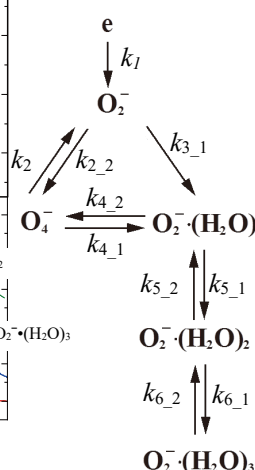


Fig. 2 Reactions of ions in O₂ with H₂O.