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Venus Middle Atmosphere Chemistry

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Venus is the most similar planet to Earth, and years of research have sought to understand their similarities and differences. Yet, it is still not clear what chemical processes maintain the long-term stability of Venus' primarily CO_2 atmosphere.

CO_2 dissociates into CO and O after absorbing photons at $\upsilon \leq 210$ nm. These O atoms should combine to form O_2, and observations of intense airglow, produced via equations (1d) and (1e), confirm rapid production of O_2 on both day and night sides.

$$2O + M\,\upsilon \;\; O_2^* + M \qquad (1a)$$
$$O_2^* + M\,\upsilon \;\; O_2(a^1\upsilon) + M \qquad (1b)$$
$$O_2^* + M\,\upsilon \;\; O_2(c^1\upsilon) + M \qquad (1c)$$
$$O_2(a^1\upsilon)\,\upsilon \;\; O_2(X^3\upsilon) + h\upsilon \qquad (1d)$$
$$O_2(c^1\upsilon)\,\upsilon \;\; O_2(X^3\upsilon) + h\upsilon \qquad (1e)$$

(O_2^* is an excited state; M is any third body.) CO and O_2 are sufficiently stable that an initially pure CO_2 atmosphere would rapidly evolve to have 7-8% CO and 3.5-4% O_2 [1]. The observed upper limit on O_2 (0.3 ppm [2]), however, indicates catalytic mechanisms, such as equation (2) [3,4], rapidly convert CO and oxygen into CO_2.

$$Cl + CO + M\,\upsilon \;\; ClCO + M \qquad (2a)$$
$$ClCO + O_2 + M\,\upsilon \;\; ClC(O)OO + M \qquad (2b)$$
$$ClC(O)OO + Cl\,\upsilon \;\; Cl + ClO + CO_2 \qquad (2c)$$
$$\underline{ClO + O\,\upsilon \;\; Cl + O_2} \qquad \underline{(2d)}$$
$$\textbf{\textit{net:}}\ CO + O\,\upsilon \;\; CO_2 \qquad (2)$$

Recent work evaluated other mechanisms, equations (3) and (4), for producing CO_2, which could be important depending on the rates of poorly constrained reactions.

$$CO + O_2(c^1\upsilon)\,\upsilon \;\; CO_2 + O(^1D) \qquad (3)$$
$$CO + O + \text{aerosol}\ \upsilon \;\; CO_2 + \text{aerosol} \qquad (4)$$

The current understanding of Venus middle atmosphere chemistry, the state of lab data, and prospects for advances based on *Venus Express* will be reviewed.

Keywords: Venus; atmospheric chemistry; planetary atmospheres; CO_2

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