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THREE-BODY ELECTRON ATTACHMENT PROCESSES IN H_2O, CO_2, AND THEIR MIXTURES

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Abstract Three-body attachment processes have been measured and calculated in oxygen and its mixtures with nitrogen [see e.g., Chanin 1962, Grünberg 1969, de Urquijo 2024], where an electron is captured by O_2, leaving it in an excited state, O_2^{-*} which, after a second collision with an O_2 molecule, is stabilised. Using a pulsed Townsend apparatus (see e.g., de Urquijo 2024 and references therein) we have explored the low E/N (electric field to gas density) region between 0.1 and 30 Td (1 Townsend=10^{-17} V cm^2) and gas pressures up to 800 Torr. Over this E/N range, only electron attachment processes of the resonant type may take place since the electron energies lie below the threshold for molecular dissociation to occur. Pure H_2O and CO_2 have been studied together with the mixtures of H_2O with He, Ar and CO_2, as well as those of CO_2 with N_2. In all cases, we have found that the density-normalised attachment coefficient, η/N, depends inversely on N, contrary to the case of three-body electron attachment in oxygen, where η/N is directly proportional to N. Past this E/N regime, binary collisions occur, and dissociative attachment takes place, with η/N independent of N. To our knowledge, this three-body attachment process has hitherto not been reported. Based on a successful beam experiment (see, e.g. Allan 2011), we propose a two-step, three-body collision process in which an electron collides with the molecule, raising it to an excited state, CO_2^*, thereby enabling it to capture a second electron to form CO_2^{-*}. This unstable anion has a measured mean lifetime of 25 μs, independent of pressure and E/N, which is suggestive of autodetachment. In the case of H_2O^-, of which we only find theoretical work (see e.g. Houfek 2016), we have found that under swarm conditions this ion forms clusters readily, the mobility of which has been measured, and is pressure dependent. Together with the above, electron attachment coefficients, electron and ion drift velocities, longitudinal diffusion and effective ionisation coefficients will be presented. Regarding the latter, findings of Penning ionisation in H_2O-He mixtures will be discussed, as well as the effects of negative differential conductivity on the drift velocity and longitudinal diffusion.

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