ATMOSPHERIC PRESSURE GENERATION OF $O_2(a^1\Delta_g)$ BY MICROPLASMAS

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Abstract. The generation of singlet oxygen, $O_2(a^1\Delta_g)$, states by microplasmas has been studied experimentally. In the present paper, the authors report experimental results showing that micro-cathode sustained discharges (MCSD's) can be used to generate high fluxes of $O_2(a^1\Delta_g)$ at atmospheric pressure. In He/O_2/NO mixtures, $O_2(a^1\Delta_g)$ number densities higher than 10^{16} cm^{-3} were measured in the MCSD afterglow at total flow rates up to 30 ln/min, resulting in $O_2(a^1\Delta_g)$ fluxes above 10 mmol/h, which could give rise to a wide range of new applications.

1. INTRODUCTION

Singlet oxygen $O_2(a^1\Delta_g)$, the first electronically excited low-energy (0.98eV) state of molecular oxygen, possesses an extremely long radiation time of more than 73 min. Moreover, this metastable state of molecular oxygen is very resistive against homogeneous and heterogeneous relaxation processes, which makes it possible to be used far away from its place of production. As so, this unique molecular species, having excitation energy ~1eV, can be used as an energy donor for a large spectrum of applications: lasers, combustion, depollution, biology, medicine, among others.

The production of $O_2(a^1\Delta_g)$ by electrical discharges has recently attracted much attention because of its potential application for the pumping of the oxygen-iodine laser [1-6]. Furthermore, singlet oxygen is also well known to produce cytotoxic effects [7] and it has been shown to be an important agent in biophysical and biochemical processes [8,9]. As so, sources of high fluxes of $O_2(a^1\Delta_g)$ molecules generated at atmospheric pressure and transported to targets some 10's cm downstream are of potential interest for biological applications.

In order to efficiently produce high concentrations of $O_2(a^1\Delta_g)$ needed for these applications, an electric discharge source must satisfy two conditions: i) it must be stable at high pressure and high power loading and ii) it should operate at low reduced electric field [10]. High-pressure, non-self-sustained discharges seem to be the most attractive option for generating stable discharges at atmospheric pressure and low reduced field. Recently, we demonstrated [11-12] that the so-called micro-cathode sustained discharge (MCSD) can be operated as a non-self-sustained discharge, satisfying the previously mentioned conditions. Different kinds of non-self sustained discharges have been extensively investigated for $O_2(a^1\Delta_g)$ production: i) the e-beam sustained discharges [3,6,13], ii) the crossed spiker-sustainer discharges [14,15], iii) the controlled avalanche method [16], and iv) the MCSD [11]. Among all these methods, the MCSD is the only discharge technique which has been proven capable of generating high $O_2(a^1\Delta_g)$ concentrations at atmospheric pressure [12,17]. This opens opportunities for a large spectrum of new applications, especially for biological decontamination [7].

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