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Abstract

Laminar Burning Velocities of Stoichiometric Inert-Diluted Methane-N2O Flames †

Maria Mitu *, Codina Movileanu, Venera Giurcan, Adina Magdalena Musuc and Domnina Razus

"Ilie Murgulescu" Institute of Physical Chemistry, Romanian Academy, 060021 Bucharest, Romania; cmovileanu@icf.ro (C.M.); venerab@icf.ro (V.G.); amusuc@icf.ro (A.M.M.); drazus@icf.ro (D.R.)

* Correspondence: maria_mitu@icf.ro

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Abstract: Combustion and explosion of combustible mixtures are a major hazard that can occur anywhere from industry to energy use in households and, therefore, protective measures must be taken to limit these undesirable events. This study pays attention to the laminar burning velocity, an important parameter involved in the combustion process. The experimental laminar burning velocities of stoichiometric methane-nitrous oxide mixtures in the presence of diluents (50 vol% inerts: argon, helium, and carbon dioxide) were calculated from pressure-time records obtained in a spherical vessel with central ignition, using a correlation based on the cubic law of pressure rise during the early stage of explosion. The nitrous oxide (N2O)-based mixtures are frequently used as propellants in propulsion systems and supersonic wind tunnels, due to the nontoxicity, high saturation pressure, and the exothermic property during decomposition. However, N2O is an oxidizer that can cause safety concerns in technical applications where it is involved. The experimental data were compared with data from the literature on stoichiometric methane-nitrous oxide mixtures diluted with nitrogen and with the calculated laminar burning velocities obtained by numerical modelling of their premixed flames. The modelling was performed with Cosilab package, using GRI 3.0 mechanism, based on 53 chemical species and 325 elementary reactions. The influence of initial pressure (0.5 bar–1.75 bar) of stoichiometric inert-diluted methane-nitrous oxide mixtures on laminar burning velocities, maximum flame temperature, heat release rate, and peak concentrations of main reaction intermediates was investigated and discussed. Using the correlations of the laminar burning velocities with the initial pressure, the pressure exponent and overall reaction order of methane oxidation with nitrous oxide were determined. Obtaining a clear perspective on the laminar burning velocities of these flammable mixtures is of great importance for both assessing fire and explosion risks and guaranteeing safety in chemical and process industries.

Keywords: laminar burning velocity; methane; nitrous oxide; inert

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