Determination of the Emissivity of the Tungsten Hexa-Ethoxide Pyrolysis Flame using Fourier Transform Infrared (FTIR) Spectroscopy

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Abstract: To determination the temperature using infrared cameras, the following issues need to be addressed, the emissivity of the object and atmospheric path effects. The later is negligible in the setup used. In this paper we present the emissivity of the flame determined from the transmissivity measured using the FTIR Spectroscopy.

1. Introduction

Laser pyrolysis is a versatile non-equilibrium thermodynamics technique used to synthesize nanoparticles. The technique is based on the absorption of a CO_2 laser by the stream of reactants constituted of liquid in the form of aerosols. The reaction happens with an invisible flame in the reaction zone. The process involves rapid heating and cooling rates, which lead to the decomposition of reactants. This is followed by rapid nucleation and growth of nanoparticles. The temperature of the flame in the reaction zone can be changed by altering the power of the CO_2 laser [1]. In the reaction zone, the temperature can be measured using contact or noncontact techniques. In the setup used, it was not possible to employ contact technique since the flame in the reaction zone was not visible to "naked eyes" and also this was going to extract heat from the flame. An infrared (IR) camera was utilized to measure the temperature of the flame. We address one of the major issues, the emissivity of the flame that needs to be measured prior to the determination of temperature using infrared camera. Emissivity of the object is the ratio of the radiation emitted from the surface of the object to that emitted by a blackbody at the same temperature [2].

2. Emissivity Measurements

Infrared (IR) cameras have been use in industrial applications for many years, and their accuracy is often limited by the uncertainty in the emissivity of the object. In this study, FTIR Spectroscopy was used to measure the transmittance of the flame and the emissivity was inferred by the use of Kirchhoff's law [3]. The spectral absorptivity (α_λ) equals the spectral emissivity (ε_λ) so that,

$$\varepsilon_\lambda = 1 - (\rho_\lambda + \tau_\lambda), \qquad (1)$$

where, (τ_λ) is spectral transmissivity, (ρ_λ=0) is the spectral reflectivity. Figure 1 shows the schematic of the experiment setup used to measure the transmittance of the flame.

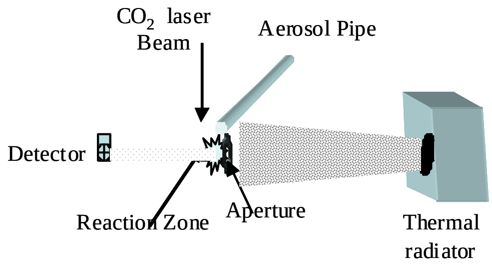

Fig. 1: A schematic representation of the experimental setup used to measure the transmittance of flame

Figure 2 shows the spectral emissivity of the flame calculated from the transmittance data of the flame obtained from a 20 W laser beam.

3. Summary and Conclusion

The transmittance of the flame was measured using FTIR spectroscopy and the data obtained was used to determine the emissivity of the flame. The temperature of the pyrolysis flame obtained using a 20 W CO_2 laser is 695.52 K.

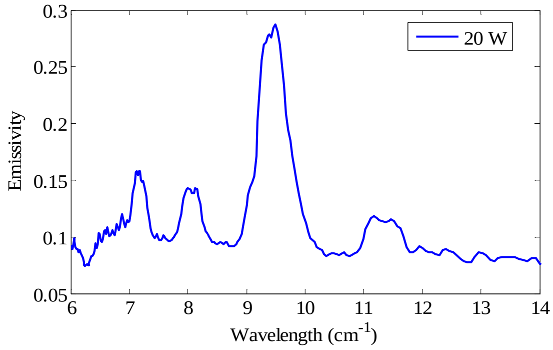

Fig. 2: Spectral emissivity of tungsten hexa-ethoxide pyrolysis flame at 20 W.

3. References

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