Current Progress in Atomization and Spray Technology for Medical Applications

Muh-Rong Wang*, Kun-He Yang, Chun-Hsien Chiu, Yang-Sheng Huang
Institute of Aeronautics and Astronautics
National Cheng Kung University
No.1, University Road, Tainan, 701, Taiwan, R.O.C.

Abstract

This paper describes the development of the atomization and spray system for medical applications. Micro-atomizers had been developed to produce the micro spray for drug inhalation. The air-assist micro-atomizer (AMA) is used to investigate the mechanisms and performance of liquid atomization. The effects of liquid properties, liquid flow rate, and atomizing air on the production of micro-spray are described. The micro-atomizer is fabricated via MEMS bulk machining processes. The hydraulic diameter of the orifice of the micro-atomizer is 78μm with aspect ratio of 13. The liquids employed in this study are water, ethyl alcohol, sodium chloride solution, and a glycerin-water mixture. The atomizing air pressure varied from 1 to 5 bar with volume flow rate less than 1L/min, and the corresponding liquid flow rate ranging from 1 to 2mL/min. The liquid sheet was first sandwiched between two sheathed air streams inside the mixing chamber. The sheathed stream was then discharged through the micro orifice. In order to evaluate the feasibility of drug delivery to lung with AMA, the mouthpiece, ball baffle, and micro-atomizer are connected in series and drop size of water spray was measured near the exit of mouthpiece. Flow visualization and imaging through a microscope and high speed camera were employed to examine the initial breakup processes. Analysis on the high speed photos shows that the breakup mechanisms of the micro-jet involved the laminar jet disintegration, aerodynamic disintegration and turbulent disintegration modes depending on the injection pressure and Weber number. The Sauter mean diameter (SMD) of the micro spray can be lowered to 5μm by adjusting the atomization pressure. The spraying performance was further enhanced as the air/liquid mass flow rate was increased and the liquid surface tension and viscosity were reduced. For example, the mean droplet size was dropped to 3.7μm in the test of ethyl alcohol with a lower surface tension. On the other hand, SMD of the glycerin-water spray is larger than that of the water spray because of the higher viscosity of glycerin. Results also indicate that the finer micro spray with Sauter mean diameter of 3μm can be achieved as a ball baffle was installed at the exit of the atomizer, under the test conditions of the air pressure greater than 2bar and the liquid flow rate ranging from 1 to 2mL/min. It can be use to meet the requirement of drug inhalation for respiratory care. Needle-free injection can be used to reduce the risk of cross contamination and is an easy way to handle drug delivery without the professional skill. It utilizes a high-speed stream to penetrate the skin or the tissues without needle. The needle-free injections with micro-pulse jets were used to deliver the nano particles to the tumor for thermotherapy. The injection of CO2 snow to the tissue was utilized for cryotherapy. Micro-injector through endoscope provides the high power injection within a short time. The mechanical strengths of the surface material of the organs are normally higher than those of the inner tissues. Hence the penetration to the organs during the needle-free injection involved the destruction of the laminated materials with different stiffness. The control of the frequency and power of the pulsed jet is important in the penetration processes of the parenchyma tissues.

Key words: Nebulizer; Thermotherapy; Cryotherapy; medical inhalation; Micro-encapsulation

*Corresponding author: Muh-Rong Wang, Email address: Wangmr@mail.ncku.edu.tw