application note

Characterizing Personal Aerosol Products using the Malvern Spraytec

Introduction

Aerosol products for personal and domestic use represent one of the largest markets for aerosol systems in terms of the number of units sold. Aerosol cans were first introduced in the 1940's as a means of applying insecticides for the control of household pests. However, the advantages of such products in terms of ease of use and storage were soon extended to other applications. Now, aerosol can delivery systems are available for everything from perfumes to deodorants and hair products. For each of these products it is advantageous to use a spray formulation in order to provide rapid application and good surface coverage.

Aerosol Particle Sizing

The particle size produced by different aerosol can systems is one of the most important factors in determining if the application of the spray can be achieved in an efficient and safe way. Although the specific requirements for particle size control change according the product that is being sprayed, in general formulators and device producers use size analysis to understand the following:

- **Spray Inhalation**: The risk of spray inhalation during aerosol use needs to be minimized. This requires the percentage of droplets less than 10 μm in size to be controlled.
- **Spray Penetration**: For products such as deodorants, the spray particles need to travel a significant distance from the

Figure 1: The Malvern Spraytec laser diffraction system.

nozzle. The penetration distance, or throw, is directly related to the droplet size, with coarse particle tending to penetrate further compared to fine particles.

- **Spray Drying and Evaporation**: The rate of drying or evaporation of spray droplets is related to their surface area, with evaporation being most rapid for fine particles. This can be important for products such as hair sprays.
- **Droplet Settling**: When applying a spray product, it is important that the particles reach the desired target. If the spray size is too coarse then gravitational settling can occur, reducing the efficiency of spray transfer.
- **Spray Drift**: Although the production of fine particles can help with overcoming gravitational setting, it can lead to problems with spray drift away from the target, reducing the transfer efficiency and risking user exposure to fine particles.

Aerosol Product Development

The majority of personal spray products use pressurized aerosol canisters containing volatile propellants to produce the spray droplets. Rapid (flash) evaporation of the volatile propellant provides the energy for atomization of the liquid formulation. Due to the amount of energy available, atomization is normally easily achieved, even for viscous formulations. Adjustment of the pressure within the can, the type of actuator used and the physical properties of the formulation allows the particle size to be optimized.

Although the aerosol characteristics need to be defined according to the application, there are also significant regulatory challenges also exist within the industry. Within Europe, recent updates to the Aerosol Dispensers Directive (75/324/EEC), coupled with the requirements of the REACH Directive, have caused manufacturers of personal and domestic aerosol dispensers to reformulate products in order to reduce user exposure to volatile organic compounds (VOCs). Manufacturers need to demonstrate that they understand the health risks associated with the use of their

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products, and where appropriate consider the risks resulting from the inhalation of the spray ejected by the aerosol dispenser under normal and reasonably foreseeable conditions of use. This is driving the need for new, advanced aerosol characterization methods.

Aerosol Characterization

The Malvern Spraytec laser diffraction system (figure 1) provides a robust, rapid method for assessing the particle size produced by aerosol systems, aiding researchers in the development of new aerosol devices and formulations.

Laser diffraction systems calculate the size of spray droplets by measuring the intensity of light scattered by particles as they pass through a collimated laser beam. The angle at which particles scatter light is inversely proportional to their size. As such, if the changes in relative scattering intensity are measured as a function of angle, it is possible to calculate the spray size distribution by comparing the acquired data to an appropriate scattering model.

The Spraytec offers many advantages for spray characterization. Data can be acquired very rapidly at a rate of one measurement every 100µs. This allows the changes in droplet size during spray actuation to be followed in real-time, enabling the atomization dynamics to be assessed. Measurement of the output of the aerosol can also be made over relatively long distances, allowing the wide spray plumes to be accurately sampled and measured. Finally, the dynamic range of measurement is large (0.1 – 2000 microns), ensuring that both fine and coarse droplets can be detected within a single measurement.

Example Results

An example of the use of the Spraytec in the characterization of personal products is shown in figures 2 and 3 for a series of hair spray formulations.

Hair sprays tend of have a median particle size of between 30µm and 60µm. The particle size distribution produced during atomization directly relates to the rate of drying and the likely formation of "beads" (obvious droplets) within the hair following application. Large particles yield long drying times and a significant amount of beading and are often produced when the polymer concentration in the hair spray formulation is high, as is the case for some "firm hold" products. Fine particles tend to dry more quickly and produce a less "tacky" feel after application, making it easier for the user to set a given hairstyle. However, they are only produced when the polymer concentration is low, reducing the achieved hold.

Figure 2 shows how the particle size varies for a "natural hold" product during a single actuation of a hair spray can. As can be seen, large particles are produced immediately after the nozzle is actuated. This is due to the fact that the flow rate through the nozzle is initially quite low. However, after around 100 milliseconds a stable particle size is obtained. The time taken for stability to be achieved is important in defining whether effective spray coverage is achieved. It also relates to how clean the operation of the device is and whether residue build-up of polymer occurs within the nozzle following repeat actuations.

The average particle size distribution produced for the stable region of the actuation profile is shown in figure 3 and is compared against two other formulations designed to produce a higher hold value. As can be seen, the distributions obtained correlate well with reported hold, with the particle size increasing as the hold value increases. This directly relates to the increase in viscosity of the formulation that is observed as the polymer concentration is increased.

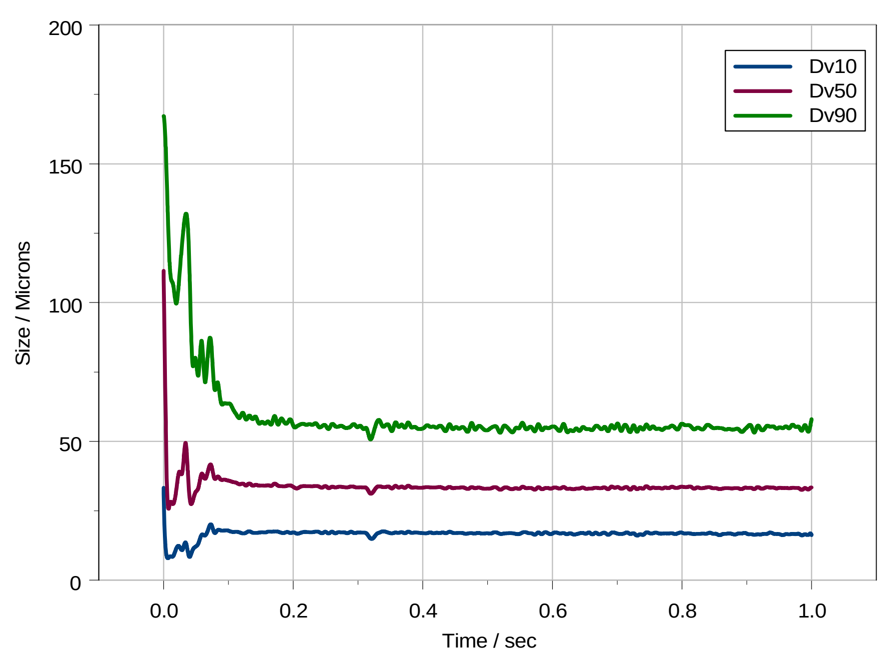

Figure 2: Size history showing the changes in particle size observed during the actuation of a hair spray product.

The production of larger particles at higher polymer concentrations would be expected to yield a tackier feel to the hair after application. The average particle size distributions also show that the volume of particles below 10 microns is low for all formulations. This is important as it suggests that the risk of spray inhalation is minimal.

Conclusions

The particle size produced by aerosol spray can systems is an important factor in controlling product efficacy and minimizing any user exposure risks. The Spraytec system provides a robust, rapid way of characterizing different spray systems, allowing changes in product performance to be correlated to the properties of the formulation that is being sprayed. This can aid with the development of new products and help with the move towards environmentally friendly propellant systems.

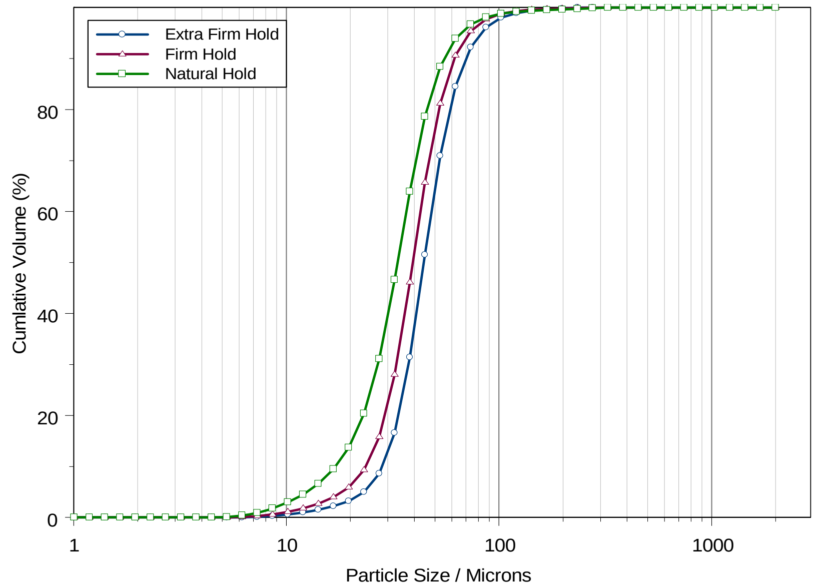

Figure 3: Average cumulative size distributions calculated for each phase of atomization observed during nasal pump spray actuation.

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