Acoustic Particle Sizing of Milk

超声法粒度分析在乳剂行业的应用

Oil/Water, as well as, Water/Oil emulsions can partially degrade or even fully break up upon undergoing dilution. Thus, particle size measurements without dilution are desirable for emulsion characterization.

油/水以及水/油的乳液会在稀释之后部分降解甚至完全分解。因此，在不稀释的情况下直接测量乳液的粒径是一种理想方法。

The APS-100 Acoustic Particle Sizer[1] measures -without the need for sample dilution Particle Size Distribution, Longitudinal Viscosity, Percent Solids, pH, Conductivity, and Temperature. Using a patented measurement design[2], the APS-100 performs acoustic attenuation spectroscopy measurements in the ultrasonic range of 1-100 MHz.

美国 MAS 公司生产的 APS-100 超声法粒度仪《1》可以不用稀释，直接测量粒度分布，纵向粘度，固含量，PH 值，电导率及温度。通过专利测量设计《2》，APS-100 可以在 1-100MHz 的超声波范围内进行声学衰减光谱测量。

The resulting attenuation spectrum of dB/cm vs. Frequency (MHz) is used by a patented first-principle algorithm[3] to calculate particle size distribution data without making assumptions regarding the shape of the particle size distribution, e.g. unimodal, bimodal, lognormal, Gaussian, etc. The APS-100 is calibrated with water without the need for particle size calibration standards.

通过使用专利的第一原理算法使用产生的 dB/cm / 频率（MHz）的衰减谱来计算粒径分布数据，而无需对粒径分布的形状进行假设，例如单峰、双峰、对数正态、高斯等。APS-100 是用水进行校准的，不需要使用粒度校准标准。

APS measurements are made by low-power (inaudible) short acoustic pulses (about 10 microseconds long) that do not affect the sample’s dispersion state as depicted in figure 1. Another instrument, the Zeta-APS, measures Zeta potential in addition to all these parameters.

APS 测量采用低功率(听不清)短声脉冲(约 10 微秒长)，不影响图 1 所示的样品的分散状态。另外 Zeta-APS 仪器，除了测量上述所有这些参数外，还测量 Zeta 电位。

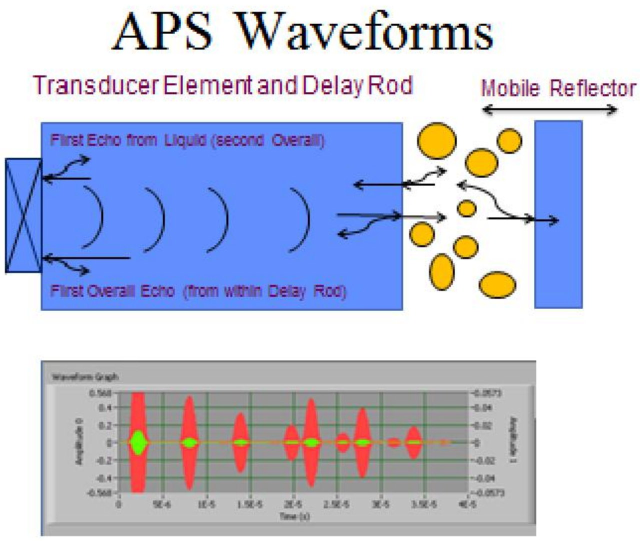

Fig. 1. Waveforms of the ultrasonic pulses applied and measured during Acoustic Particle Sizing.

图 1 - 超声波脉测量粒度的过程中，超声波的脉冲波形。

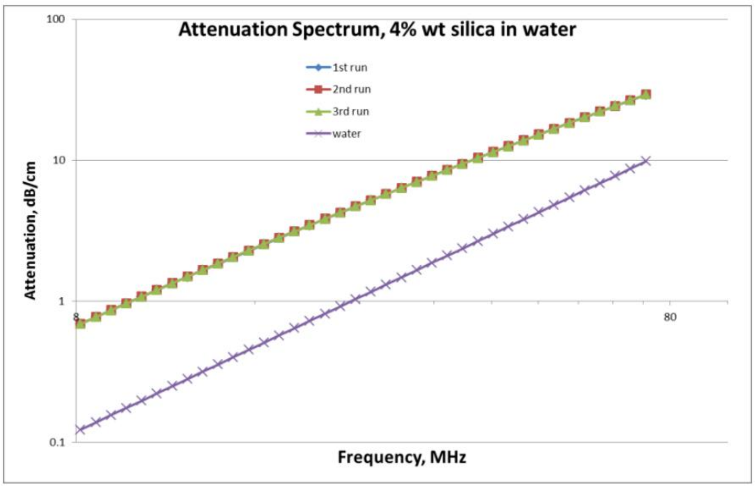

Fig. 2. Acoustic Attenuation Spectra of 4% wt silica-water sample (3 runs: ◆, ■, ▲) alongside DI water (x).

图 2 - 4%wt 二氧化硅水样（3 次：♦, ■, ▲)和去离子水的声衰减谱。

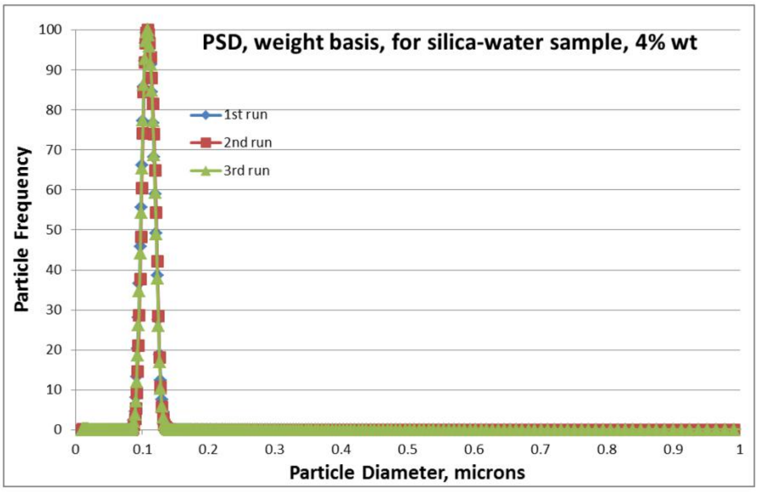

Fig. 3. Particle Size Distribution overlaid data for three consecutive runs of a 4% wt silica-water sample.

图 3 – 三次 4%wt 二氧化硅水样的粒度分布数据叠加图

Figures 2 and 3 show attenuation spectra and particle size distribution data for three consecutive runs of a silica-water sample at 4% wt percent solids level (Nissan Chemical, Houston, TX). A water (solvent) spectrum is also shown. A solvent spectrum (excluding the particles) is required for particle size computation.

图 2 和图 3 显示了连续三次 4%wt 二氧化硅水样的粒度分布和声衰减谱（Nissan Chemical, Houston, TX）。水样的谱图也有显示。粒径计算需要溶剂谱(不包括微粒)。图 3 所示的 PSD 在 0.1 微米有相当窄的分布，接近 MP1040 二氧化硅的标称平均粒径。

Emulsion Analysis

乳液测试分析

For this study, five consumer-type dairy samples were characterized as follows:

在本研究中，五种消费型乳液样本的特征如下：

- Half and Half Cream (HHC) 半脂乳

- Whole Milk (WM) 全脂乳

- 1% Low-fat Chocolate Milk (CM) 1% 低脂巧克力乳

- 1% Low-fat Milk (LFM) 1% 低脂乳

– Nonfat Milk (NFM) 脱脂乳

The samples were analyzed without dilution. They were continuously mixed by the APS-100's onboard mechanical mixer. Sample temperature was kept at 26 ºC by the APS- 100's sample heater.

这些样品没有进行稀释。他们是由 APS-100 的内置机械混合器连续混合。通过 APS-100 的加热系统，保证样品在 26℃。

Acoustic Data

超声数据

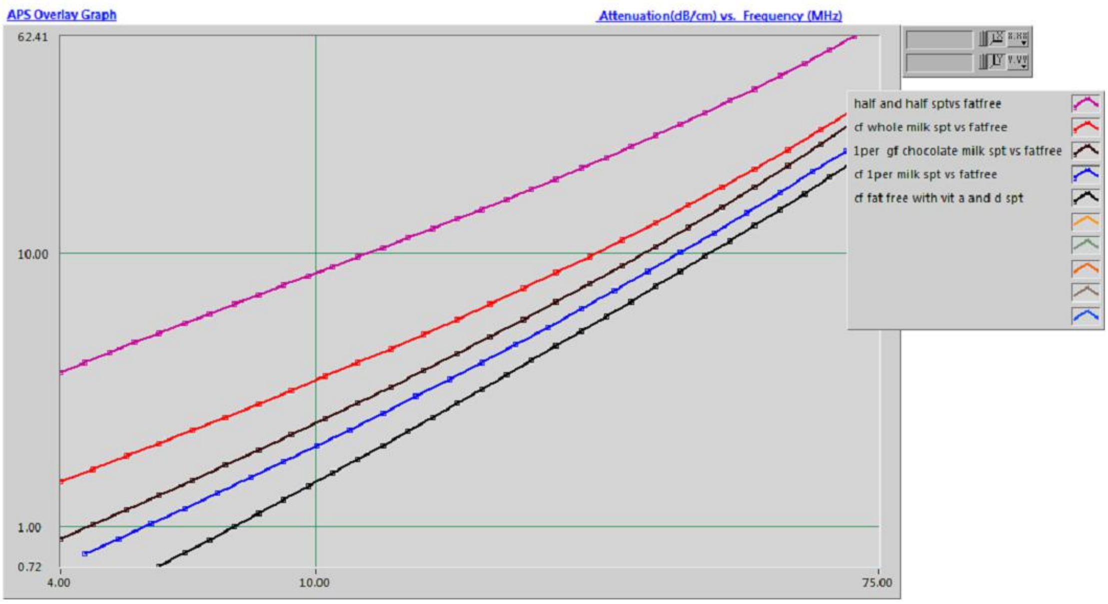

Fig. 4. Acoustic Attenuation Spectra for five milk samples.

图 4 – 5 种乳剂样品的超声衰减波谱。

Figure 4 shows acoustic attenuation spectra, dB/cm vs. Frequency (MHz), for the five milk samples. Attenuation levels decrease in the following order due to each sample's fat content level as follows (see below about the 1% chocolate milk sample):

HHC > WM > CM > LFM > NFM

图 4 显示了 5 种乳的 dB/cm / 频率（MHz）的衰减谱。由于每个样品的脂肪含量水平，衰减水平按以下顺序降低（见下文关于 1%巧克力牛奶样品）：

HHC 半脂乳 > WM 全脂乳 > CM1% 低脂巧克力乳 > LFM 低脂乳> NFM 脱脂乳

Regarding Chocolate vs. Low-fat milk, the difference in attenuation is due to the added chocolate flavor components.

关于巧克力和低脂乳，衰减的差异是由于添加了巧克力风味成分。

These samples were analyzed at 26 ºC, kept constant by the APS-100's onboard heater. Also, the samples were continuously mixed during these measurements by the APS-100's mechanical mixer.

这些样品在分析过程中通过 APS 的加热系统保持温度在 26℃。此外，在这些测量过程中，由 APS-100 的机械混合器连续混合样品。

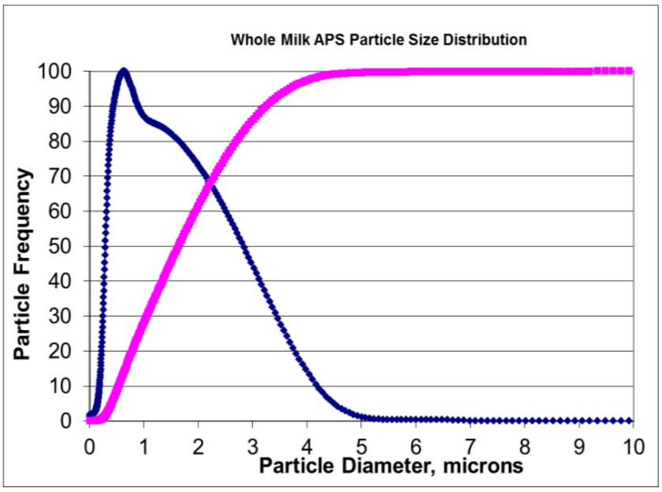

Fig. 5. Particle size distribution data for a whole milk sample by Acoustic Particle Sizing (APS-100).

图 5 – APS-100 测量的全脂乳的粒度分布数据。

Figure 5 below presents the particle size distribution for a whole milk sample analyzed without dilution. The fat-free milk sample was used to represent the intrinsic attenuation required by the acoustic particle sizing computations[4].

图 5 显示了未经稀释而分析的全脂乳的粒度分布。脱脂乳样品用于表示声学颗粒尺寸计算所需的固有衰减《4》。

Intrinsic attenuation corresponds to the solvent attenuation, i.e. attenuation excluding the discrete phase (particles/droplets) of the sample. The particle and solvent physical properties required by the particle size computations were obtained from published data[5].

固有衰减对应于溶剂衰减，即不包括样品的离散相（颗粒/液滴）的衰减。颗粒尺寸计算所需的颗粒和溶剂物理性质是从已发表的数据中获得的《5》。

Some of the corresponding particle size data for the whole milk sample are as follows:

全脂乳样品的相应粒度数据如下

Mean particle size, Volume weighted: 1.8 µm, 25th, 75th percentiles: 0.9, 2.5 µm

Mean particle size, Area weighted: 1.1 µm, 25th, 75th percentiles: 1.46, 1.5 µm

体积平均粒径：1.8µm，D25 为 0.9µm，D75 为 2.5µm

面积平均粒径：1.1µm，D25 为 1.46µm，D75 为 1.5µm

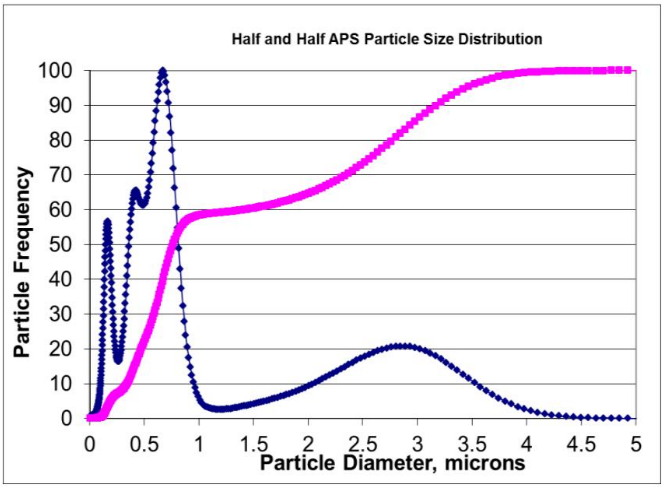

Figure 6 above corresponds to a sample of half and half creamer measured by an APS- 100 instrument without dilution. The particle size data is as follows:

Mean particle size, Volume weighted: 1.45 µm, 25th, 75th percentiles: 0.53, 2.6 µm

Mean particle size, Area weighted: 0.65 µm, 25th, 75th percentiles: 0.2, 0.68 µm

图 6 对应的是用 APS- 100 仪器测量的没有稀释半脂乳样品的测试数据：

体积平均粒径：1.45µm，D25 为 0.53µm，D75 为 2.6µm

面积平均粒径：0.65µm，D25 为 0.20µm，D75 为 0.68µm

REFERENCES

1. Matec Applied Sciences, Northborough, MA USA, www.matecappliedsciences.com)

2. US Patent 6,604,408

3. US Patent 6,119,510

4. McClements, D. J., and Povey, J. W., *Ultrasonic analysis of edible fats and oils*, Ultrasonics, vol 30, 6, 1992.

5. Lopez, C., Briard-Bion, V., Camier, B., Gassi, J. Y., *Milk Fat Thermal Properties and Solid Fat Content in Emmental Cheese: A Differential Scanning Calorimetry Study*, J. Dairy Sci., 89:2894-2910, 2006/