Polyvinylpyrrolidone (PVP) is a polar molecule and is used in a wide variety of applications. For example, since it simply passes through humans, it is a binder in pharmaceutical tablets. Because PVP binds to polar molecules quite well, it is also used as a paper coating. PVP can also be found in shampoo, toothpaste, paint, and adhesives. Rapid, reliable characterization is important to better understand manufacturing performance, processing, and structure-property relationships. With the correct choice of instrument, molecular weight determination of PVP is routine.

PVP obtained from Aldrich was dissolved in water and data were collected with a BI-MwA in batch mode. A significant problem in light scattering is dust and the BI-MwA design provides a solution with its sealed flow system and automated dust rejection algorithms. Both of these features eliminate the deleterious effects of dust.

Values for $Kc/\Delta R$ were automatically calculated with the BI-MwA software. Here, $K$ is the Debye constant and it is proportional to the square of the refractive index increment, $dn/dc^1$. A value of 0.174 mL/g is used for $dn/dc$. $c$ is polymer concentration, and $\Delta R$ is proportional to the excess scattered intensity.

To determine molecular weight, the software then generates a Zimm, Berry, or Debye plot and values for molecular weight, radius of gyration (except for the case of a Debye plot), and second virial coefficient are calculated and displayed. After extrapolation to zero angle and zero concentration, the quantity $Kc/\Delta R$ is equal to the reciprocal of the weight-average molecular weight ($M_w$). The $M_w$ determined by fitting is $(5.490 \pm 0.030) \times 10^4$ g/mol.

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1 For vertically polarized light, as in the case of the BI-MwA and other modern light scattering instruments,

$$K = \frac{4 \pi^2 n^2 (dn/dc)^2}{(N\lambda^4)}$$

where $n$ is the solvent refractive index, $N$ is Avogadro’s number, and $\lambda$ is the wavelength of the laser in vacuum.
The radius of gyration ($R_g$) determined by fitting is 18.1 nm. Note that this radius of gyration is much larger than one expects from such a low molecular weight polymer. Typically, random coil polymers with a molecular weight of less than 75,000 g/mol are Rayleigh scatterers since their $R_g$ is less than 12 nm. The value of $R_g$ determined by light scattering is the so-called $z$-average, an average weighted by the square of molecular weight. Since the PVP sample is polydisperse, this explains the high value of $R_g$.

The second virial coefficient ($A_2$) obtained by fitting is $4.33 \times 10^{-4}$ cm$^3$ mol/g$^2$. Since this value is positive, it indicates that water is a thermodynamically good solvent for PVP. For comparison, the second virial coefficient of molecular weight 55,000 g/mol PS in THF is $7 \times 10^{-4}$ cm$^3$ mol/g$^2$.

These data show that the BI-MwA can be used to determine the molecular weight of PVP.