shown to be reversible, since the micellar architecture was maintained after lowering the temperature below the LCST (Chung et al., 1999).

Copolymers such as poly(*N*-isopropylacrylamide) (PIPAAm) in aqueous solution are well known to exhibit a thermoresponsive phase transition (32°C for PIPAAm) (Heskins and Guillet, 1968). The copolymers, water soluble and hydrophilic, usually show an extended chain conformation below their LCSTs, undergoing a phase transition to an insoluble and hydrophobic aggregate above the LCSTs. This phase transition for PIPAAm remarkably occurs with narrow temperature changes through the LCST and is reversible corresponding to temperature changes (Chung et al., 1999).

CPs of copolymers can be determined using the optical transmittance method (Chung et al., 1999), and even using a visual observation method (Pandya et al., 1993). Optical transmittance of aqueous polymer solutions at various temperatures can be measured using a UV/visible spectrometer. Sample and reference cells are thermostated with a circular water jacket, and the sample is monitored for the onset of turbidity. For the visual observation method, copolymer solutions at different concentrations are measured by heating them in glass tubes immersed in a well-stirred heating bath. The temperature of first appearance of turbidity is taken as the CP. For both methods, the samples must be well stirred.

### Core Viscosity

The viscosity of the micellar core may influence the physical stability of the micelles as well as drug release (Jones and Leroux, 1999). The intrinsic viscosity of the hydrophobic core, or microviscosity, can be determined by using fluorescent probes such as bis(1-pyrenyl-methyl) ether (dipyme) (Winnik et al., 1992), 1,2-(1,1°-dipyrenyl)propane (Kwon et al., 1993a,b), or 1,6-diphenyl-l,3,5-hexatriene (DPH) (Ringsdorf, 1991). Dipyme is sensitive to both polarity and viscosity changes in its local environment. The extent of intramolecular excimer emission depends upon the rate of conformational change of the chain linking the two pyrenyl groups. The local friction in the environment causes resistance to motion (Winnik et al., 1992). As a consequence, the excimer to monomer intensity ratio (*IE*/*IM*) provides information on the microviscosity of the dipyme local environment. A small ratio correlates with a low mobility and a solid-like core. Winnik et al. (1992) showed with dipyme that the microviscosity of the inner core of poly(*N*-isopropylacrylamide) (PNIPA) micelles was dependent on the position of the hydrophobic moiety (random versus end-grafted chain).

Internal viscosity can also be obtained from the depolarization of DPH (Ringsdorf, 1991; Zhang et al., 1996b). Anisotropy values are directly related to the rotational freedom of DPH: the higher the local viscosity of the associated DPH region, the higher the anisotropy values will be (Ringsdorf, 1991).

Chung et al. (1999) used 1,3-bis(1-pyrenyl) propane ($PC_3P$) as a sensitive probe for local viscosity measurements (Almeida et al., 1982; Zachariasse et al., 1982) by forming an intramolecular excimer. In the emission spectra for $PC_3P$ in PIPAAm and PIPAAm-*b*-PBMA solutions above their CMC as a function of temperature, PIPAAm solutions showed a continuous reduction in *IE*/*IM* as the temperature increased below the LCST, since hydrophobic polymer-rich phases solubilizing $PC_3P$ probes were getting rigid as the polymer chain dehydrated. However, the value of *IE*/*IM* discontinuously decreased by a temperature increase through the LCST, implying the phase transition of PIPAAm chains. Above the LCST, it remains essentially unaffected by further temperature increase. It implied that the motion of $PC_3P$ is suppressed by the microviscosity created by hydrophobic contracted polymer chain aggregation. On the other hand, the ratios (*IE*/*IM)* of $PC_3P$ dissolved in PIPAAm-*b*-PBMA micelle solutions were markedly lower than those of PIPAAm solutions over the entire temperature region, owing to highly compact cores of aggregated PBMA chains.

$^1$H-nuclear magnetic resonance (NMR) also provides some information on the viscosity of the micellar core (Jones and Leroux, 1999). The copolymers are usually dissolved in D2O and in a solvent where micelle formation is not expected and where all the peaks proper to the hydrophilic and hydrophobic part of the polymer can be detected (e.g., $CDC_{13}$). In $D_2O$, the presence of micelles