10 Ion mobility spectrometry

10.1 General design of spectrometers

Ion mobility spectrometry was developed for the simple and cheap detection and characterization of organic compounds (Cohen and Karasek, 1970; Karasek, 1970; Caroll et al., 1971; Caroll, 1972; Cohen et al., 1972; Cohen and Crowe, 1973; Vora et al., 1987; St. Louis and Hill, 1990; Campbell et al., 1991; Burke, 1992; Eiceman and Karas, 1994; Taylor, 1996; Baumbach and Stach, 1998; Baumbach and Eiceman, 1999; Saurina and Hernandez-Cassou, 1999; Asbury and Hill, 2000; Purves et al., 2000; Wu et al., 2000; Beegle et al., 2001; Eiceman et al., 2001; Matz and Hill, 2001; Stone et al., 2001). The ion mobility spectrum reflects the ion mobilities which correlate well with the size-to-charge ratios of the sample compounds.

In the ion mobility spectrometer (IMS), (a) sample molecules in the vapor phase are ionized, (b) the charged sample molecules (ions) are accelerated by an electric field, and (c) their time of flight in the gaseous medium of the drift channel is measured and recorded (Figs. 10.1–10.6). These simple spectrometers can detect and analyze astonishing tiny traces of small and as well large molecules and clusters.

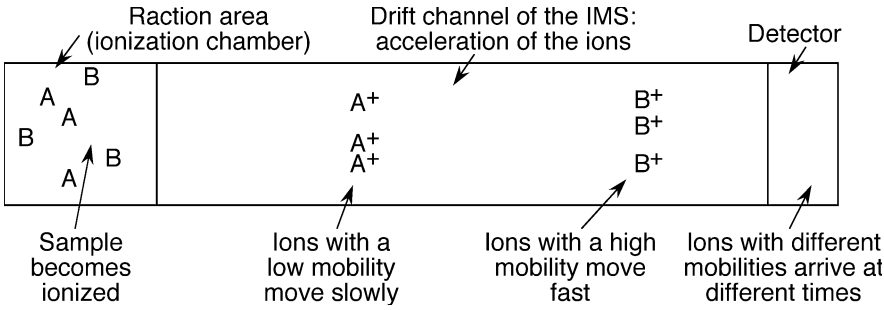

Fig. 10.1 Principle of operation of ion mobility spectrometers: Molecular ions are generated and accumulated in the reaction area. A gating pulse transfers the molecular ions to the drift channel where said ions are accelerated by an electric field. Ions with different mobilities in the gaseous medium of the drift channel arrive at different times at the detector

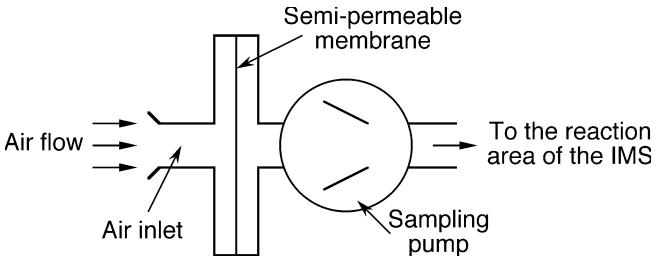

Fig. 10.2 Design of a sample inlet for an IMS. The sampling pump draws air through the semi-permeable membrane which attenuates the influx of large dust particles and other interferents (see also Spangler, 1982). A suitable membrane is, e.g., a 5–50 µm polytetrafluoroethylene (PTFE) foil or silicone rubber membrane (Spangler and Carrico, 1983; Kotiaho et al., 1995). For IMS for detection of biological agents, a metal grid instead of a membrane may be more appropriate because of its better transparency for high molecular-weight compounds

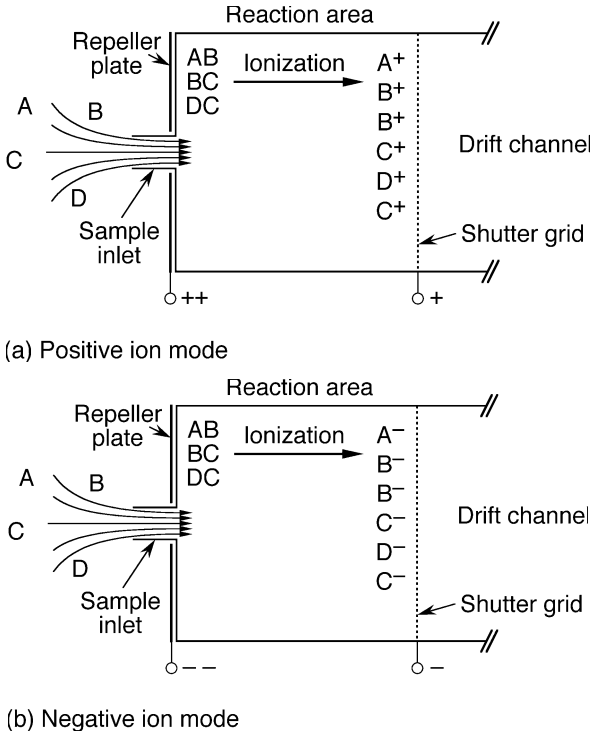

Fig. 10.3 Reactions of the sample in the reaction area. Sample molecules are ionized, either directly by dissociation or indirectly by clustering with other ions. In the positive ion mode, positive ions are repelled from the repeller plate and accumulated in front of the shutter grid. In the negative ion mode, negative ions are analogously accumulated. Many IMS operate alternatingly in the positive and negative ion mode