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Abstract

Title	Development of Novel Analytical Techniques for Evaluating In-room Air Environment

(800 words)

Precise determination of volatile organic compounds (VOCs) in in-room air has been increasingly focused in recent years due to the requirement of more accurate and systematic analysis of in-room environment. As the analytical tool of VOCs in air samples, gas chromatography (GC) is one of the most promising methods because of the excellent separation selectivity and the availability as commercial instruments, and gas chromatography-mass spectrometry (GC-MS) has been realized as a powerful tool for a sensitive determination of typical VOCs in air samples. However, the concentration of VOCs in air samples is relatively low in most cases, and the direct determination of these compounds is still quite challenging. In this thesis, novel analytical techniques for the analysis of in-room air environment are described including the development of extraction medium and separation medium. Applications of the developed techniques to the real in-room environmental analysis are also described.

In Chapter 1, general introduction of this thesis including the aims and scope of the study is described along with the background of this work.

In Chapter 2, novel packed-capillary columns for gas chromatography were developed with a thin-wall stainless steel capillary having typical internal diameter of 1.0 mm. After a fundamental evaluation of the compatibility of these packed capillary columns with typical temperature-programmed separations, rapid temperature-programmed separations were also conducted on the basis of mathematical analysis of the retentions in the preliminary temperature-programmed runs. The results suggest that the new packed capillary columns provide a good separation performance comparable with that of the conventional particle-packed columns. The performance of rapid temperature-programmed operations with the developed packed-capillary columns could be quite satisfactory for almost all separations currently performed in typical analytical laboratories.

For a systematic evaluation of indoor air environments in school facilities, a rapid on-site air-sampling technique was developed with a miniaturized needle-type sample preparation device in Chapter 3. The in-needle extraction device was prepared with particles of activated carbon and divinylbenzene polymer, and various types of volatile organic compounds (VOCs) were successfully extracted with the developed needle extraction device. The results clearly showed that the levels of VOCs in most rooms sampled in school facilities could be successfully determined, allowing a systematic analysis of in-room air environment in schools. The developed needle device can be widely applied to indoor air analysis in other types of facilities such as rooms in hospitals and hotels.

In order to evaluate the adsorption performance for typical organic pollutants, a novel cross-linked chitosan phase was synthesized and the interaction between the chitosan phase and aromatic compounds was studied in Chapter 4. The chitosan phase was prepared with a novel cross-linking reagent having both aliphatic and aromatic functionalities, and employed as the stationary phase in liquid chromatography. As the model sample probes, a group of polycyclic aromatic hydrocarbons was introduced, and the retention behavior was compared with that obtained from several commercially available stationary phases including monomeric and polymeric octadecylsilicas (ODSs). The results clearly demonstrate a potential applicability of the newly synthesized chitosan phase as the stationary phase in chromatographic methods and as novel wall paint or wallpaper materials for reducing VOCs in indoor air environments.

Introducing a novel polyimide material as the extraction medium of the miniaturized sample preparation device for air samples, the preconcentration of VOCs was simultaneously carried out at the time of the sampling as described in Chapter 5. Spherical polyimide particles having a typical diameter of 5 μm were packed into a microscale sample preparation tube, and used for the sample preparation of typical VOCs existed in-room environment. Taking advantage of a good stability of the polyimide material to organic solvent, the developed polyimide-packed tube showed a good performance as the sample preparation medium with an effective and quick desorption by a typical organic solvent.

Finally, the overall conclusion of this thesis is summarized in Chapter 6.