ADSORPTION OF FORMALDEHYDE INTO CHARCOAL BOARDS AND THEIR APPLICATION TO BUILDING MATERIALS FOR HOUSES

Yukie Akagi, Tomoaki Sakaguchi, Tomoya Yoshimatsu, Shinpei Yamasaki, Terunobu Manabe, Mitsuhiro Sakawa, Kochi University of Technology, Kochi, Japan

Abstract

Recently, effective applications of untapped natural materials, such as thinned wood and waste wood, are necessary. As one usage of these unused woods, SUMIYA Co., Ltd. has developed a new type of building board by carbonising waste wood. This charcoal board can adsorb volatile organic compounds (VOCs) which cause sick building syndrome. In the previous research, we discovered that the charcoal board has superior ability to adsorb formaldehyde. In addition, we also found out that formaldehyde adsorbed to the board transforms into formic acid. If this formic acid decomposes into other harmless substances, this charcoal board may be able to keep adsorbing formaldehyde without causing saturation. In this study, the adsorption rate and the transformation mechanism of formaldehyde are investigated as a procedure for calculating the service life of the charcoal board. To explore the adsorption rate, the concentration of formaldehyde was measured at particular intervals. After that, white deposits gained from the charcoal board were analysed to clarify the transformation of formaldehyde. As a result, the deposits were identified as formaldehyde trimer known to transform into formic acid or low polymer. Therefore, this charcoal board has a possibility of semiparmanent adsorption by concentrating formaldehyde from gas to liquid and solid.

(Keywords: Adsorption, Charcoal, Porous carbon)

Introduction

From the viewpoint of saving resources, effective uses of untapped natural resources are urgently needed. Therefore, it is important for waste management and tree thinning business to use surplus wood materials such as thinned wood or waste wood effectively. These forest resources can be reproduced, and using wood biomass promotes new employment in the rural area. For these reasons, SUMIYA Co., Ltd. has developed a new type of charcoal board by using carbonized thinned wood. The boards are composed of various types of charcoals, and have the property of absorbing VOCs (Volatile Organic Compounds) that cause Sick House Syndrome. These boards are beginning to be commercialized (Figure 1).

It is known that charcoal can absorb various gases such as formaldehyde or tolunene, one of VOCs, and we had discovered that absorbed formaldehyde changes into formic acid in the previous experiment. Therefore, charcoal has the potentiality of semipermanent formaldehyde absorption without causing saturation. The boards may be widely used as ventilation-free and maintenance-free products if they absorb gases well over a long term. In this research, we have examined if the boards will absorb these gases over a long term for practical application. As a method of advancing the research, we have studied the concrete reaction rate law of the formaldehyde absorption and the formic acid conversion, and the influence of the charcoal properties on the formaldehyde absorption rate.

Figure 1. Construction examples. The charcoal boards masked with Japanese paper was used for wall.

Experiments

Absorption and conversion rate

First, to find the absorption rate law of charcoal, formaldehyde concentrations were measured at particular intervals (Figure 3). The charcoal was put in formaldehyde gas that was adjusted in various concentrations at constant temperature and humidity (Figure 2). The relation between the gas concentration and the absorption rate was examined by evaluating the reaction order. As a result, the reaction order of formaldehyde absorption became neither primary nor integral but about 1.6 (Figure 4).

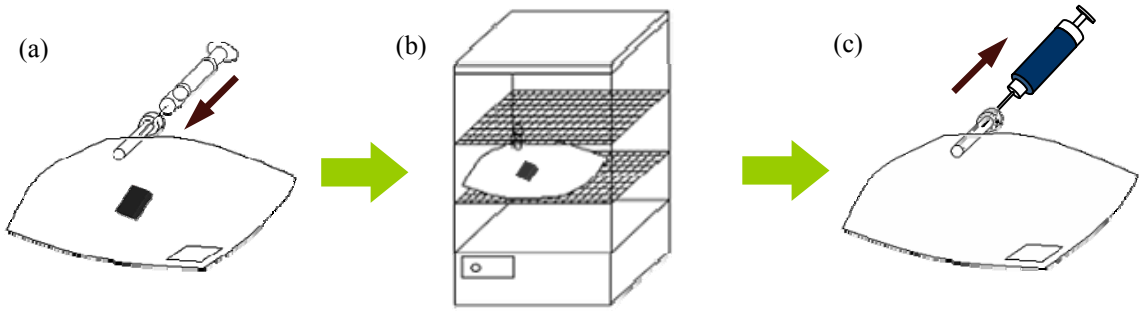

Figure 2. The procedure of the absorption test. (a) formaldehyde gas was injected in a Tedlar® bag, (b) the bag was left at constant temperature and humidity, (c) formaldehyde concentration was measured.

Second, the rate law that the absorbed formaldehyde changes into formic acid was examined. The charcoal used in this experiment was soaked in formaldehyde solution that was adjusted in constant concentration, and laid at constant temperature and humidity. Incidentally, it was discovered that the concentration of formed formic acid decreases after a certain time. The cause for decreasing formic acid concentration was also examined.

Relation between charcoal properties and formaldehyde absorption

Charcoal absorbs formaldehyde easily when its ratio surface area is larger than the particular ratio surface area. Furthermore, its ratio surface area depends on the carbonization temperature of the raw material. Thus, the relation between the ratio surface area of charcoal and the formaldehyde absorption rate was evaluated. The charcoals having various ratio surface areas were prepared, and used for measuring the formaldehyde absorption ratio. The correlation between the ratio surface area and the absorption rate was examined.

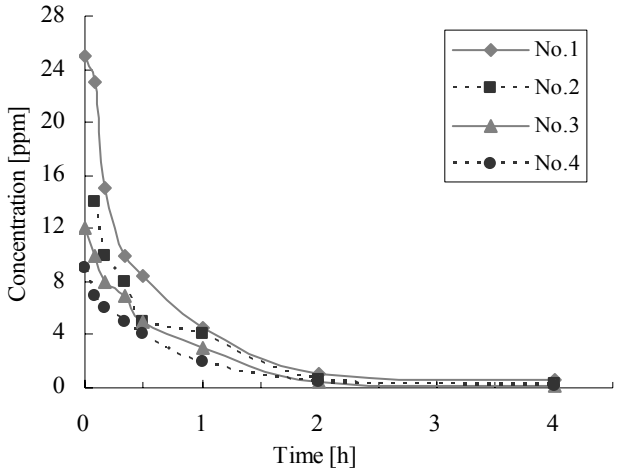

Figure 3. Absorption tests. Formaldehyde concentrations were measured at particular intervals.

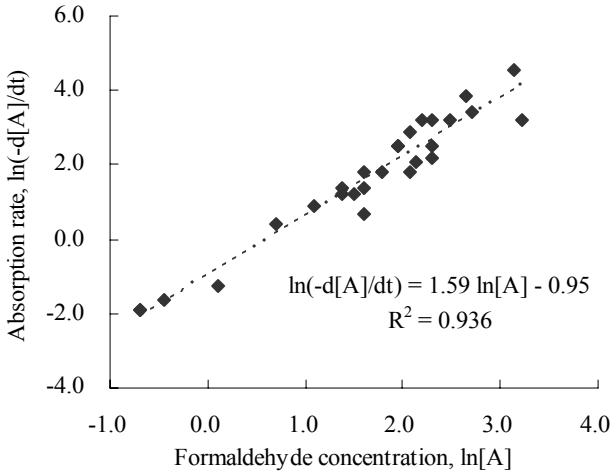

Figure 4. Relation between absorption rate and formaldehyde concentration. [A]; formaldehyde concentration, t; time [h]. The inclination of the approximation line shows the reaction order, and the y-intercept shows the logarithmic rate constant.