Chapter 19
Aroma Chip Using a Functional Polymer Gel

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ABSTRACT
Conventionally, the controlled release of aroma molecules has been achieved by employing mechanical devices; however, it has not been possible to avoid the noise and gusts of air that devices emit prior to transmitting aroma information. Another problem is the adherence of odor components to the device structure, because the aroma source is located inside or at the bottom of the device. In this chapter, the authors focus on a chemical container of a functional polymer gel (temperature-responsive hydrogel) that features a reversible phase transition between sol and gel and the controlled release of aroma molecules using a Peltier module to control temperature. By this approach, they developed a soundless olfactory display based on an aroma chip and solved the problem of the adhesion of odor components by placing a card-based aroma source (aroma-chip array) on the top of the olfactory display.

INTRODUCTION
Human beings acquire information from the external world through five senses (sight, sound, smell, taste, and touch), but traditional media such as Television (TV) and Personal Computers (PC) provide only Audiovisual (AV) information. As a consequence, users do not have access to other information modalities. The use of olfactory information, for example, may effectively promote a more realistic experience and sense of presence by transmitting aromas associated with a particular location (Washburn, 2004). With this in mind, a variety of olfactory displays have been proposed (Kaye, 2001; Yamanaka, 2002; Yanagida, 2004; Yamada, 2006; Kim, 2006).

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Previous systems, however, have employed mechanical devices to control the release of aroma molecules, which implies that the noise and gusts of air associated with the operation of such devices cannot be avoided prior to each transmission of olfactory information. For example, solenoid valves and switching devices, which are used to generate aroma molecules, make noise with the result such that users could perceive auditory information prior to olfactory information. In addition, blowers, fans, air pumps, and air compressors generate air gusts (perceptible airflow) by the use of air streams to convey aroma molecules. Hence, users can also feel a breeze before the aroma reaches them.

In short, by employing mechanical devices, while olfactory information is usually received without auditory and tactile information, noise and gusts of air would precede the aroma. Moreover, because the aroma source in such systems is usually located inside or at the bottom of the device, odor components would adhere to the structure preventing the release of different aromas using the same device.

To solve these problems, we have been focusing our research on the next generation of biomedical Drug-Delivery System (DDS). A DDS is used to ensure that drugs enter the body and reach the target area. A functional polymer gel is widely used as a drug carrier material in the DDS field (Ulijn, 2007; You, 2010). This gel acts as a kind of a chemical container or chemical valve (Beebe, 2000; Yoshida, 2010), which might be promising for the controlled release of aroma molecules without the noise and gusts of air associated with mechanical devices.

In this study, we seek to develop an effective and soundless olfactory display for generating natural olfactory information. We also attempt to solve the problem of the adhesion of odor components by placing the aroma source (aroma-chip array in an aroma card) on the top of the olfactory display.

**BACKGROUND**

**Controlled Release of Aroma Molecules**

Information related to the physical senses of sight, sound, and touch can be conveyed by a Liquid-Crystal Display (LCD), loudspeaker, and haptic device (vibration motor), respectively. Information related to chemical senses of olfaction and gustation, on the other hand, can be conveyed by an olfactory display and gustatory device (unrealized), respectively, in which case, chemical (aroma) materials for the devices must be prepared in advance.

Since ancient times, aroma materials have been used in religious practices for sterilization and as antibiotics. More recently, aroma materials have come to be used for diverse purposes including aromatherapy (Cooke, 2000) and aromachology (Jellinek, 1994). The use of aroma materials now extends to many fields, including pharmacology, food and cosmetics, household products, and Virtual Reality (VR) (Tortell, 2007).

Owing to their physical properties, aroma materials are roughly classified into liquid- and solid-type (powder) materials, the former being more widely used (Calkin, 1994). However, liquid-type aroma materials evaporate easily and are nondurable, which means that they cannot provide a prolonged effect. To overcome this hindrance, gelatinization using natural polymers can be used to achieve the controlled release of aroma molecules. The natural polymer gels commonly used include gelatin, agar, konjac, and carrageenan. However, these gels tend to be weak; they can easily deteriorate by the effects of microbes. To solve this problem, we have been focusing on synthetic polymer gels in our research.

Synthetic polymer gels for gelatinization using various types of polymerizations have been investigated to achieve the controlled release of materials. In particular, a stimuli-responsive