Computers and Chemical Engineering 65 (2014) 40–53

Contents lists available at ScienceDirect

Computers and Chemical Engineering

journal homepage: www.elsevier.com/locate/compchemeng

A knowledge-based ingredient formulation system for chemical product development in the personal care industry

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ARTICLE INFO

Article history:
Received 18 July 2013
Received in revised form 17 February 2014
Accepted 10 March 2014
Available online 19 March 2014

Keywords:
Knowledge management
New product development
Ingredient formulation
Chemical product
Personal care industry
Case-based reasoning

ABSTRACT

The formulation of personal care products involves a trial-and-error approach to testing different combinations of chemicals. Specific knowledge plays an important role in creating the desired product properties. Without knowledge support tools, the formulation process becomes iterative. Furthermore, personal care products cannot be designed without analyzing market needs, and their development thus involves the collaboration of the formulators and the marketing teams. Miscommunication can reduce the efficiency and effectiveness of the process. This paper presents a knowledge-based ingredient formulation system for supporting chemical product development in the personal care industry. Case-based reasoning is used to solve ingredient formulation problems with reference to how similar past problems have been solved. The system also acts as a collaborative platform for sharing knowledge among the various stakeholders. A case study confirms the viability of the system, and the results show that the system provides formulators with key knowledge, enabling effective product formulation.

1. Introduction

Spurred by the increasingly volatile environment, attention has shifted from process design to product development. As most chemical-based products, such as personal care products and cosmetics, are customer-oriented, new product development (NPD) cannot be isolated from marketing issues. In the conventional approach, chemical product development, especially in the personal care industry, is a cross-functional process involving two major units: (i) the Sales and Marketing Department and (ii) the Research and Development (R&D) Department, as shown in Fig. 1. Sales teams analyze the market trends and define the desired product attributes before creating a NPD enquiry for the formulators in the R&D Department. However, some product attributes are defined by the Sales and Marketing Department, such as the smoothness and softness of products, which are sensorial and thus subjective. Sales staff lack the technical knowledge to help them precisely express their preferences regarding those attributes. As a result, miscommunication between sales staff and formulators can easily occur as their perceptions of these subjective product attributes are different. If formulators interpret sales staff intentions or preferences for product attributes inaccurately, the ingredient formulation becomes iterative, lowing the efficiency and effectiveness of the entire NPD process. In addition, the ingredients involved in chemical products are often chosen based on previous experience with similar products (Cheng, Lam, Ng, Ko, & Wibowo, 2009). Without any reference to the previous similar NPD cases, formulators can make decisions based only on their own judgments. In this case, the decision quality involved in chemical product development cannot be guaranteed.

A knowledge-based ingredient formulation system (KIFS) is presented in this study for addressing the needs in practice. There are two objectives to be achieved by the KIFS. First, the KIFS must act as a knowledge-based collaborative platform for translating the product requirements from sales into NPD knowledge, supporting formulators in formulating personal care products accordingly. This will eliminate any potential miscommunication problems and will improve the efficiency of chemical product development. Second, the KIFS provides decision support to formulators in their attempt to select the most appropriate ingredient formulae. To achieve this, a knowledge-based artificial intelligence (AI) technique, namely case-based reasoning (CBR), is embedded into the system. It is used to address the new chemical development problems by utilizing the knowledge gained in solving similar past cases.

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http://dx.doi.org/10.1016/j.compchemeng.2014.03.004
0098-1354/

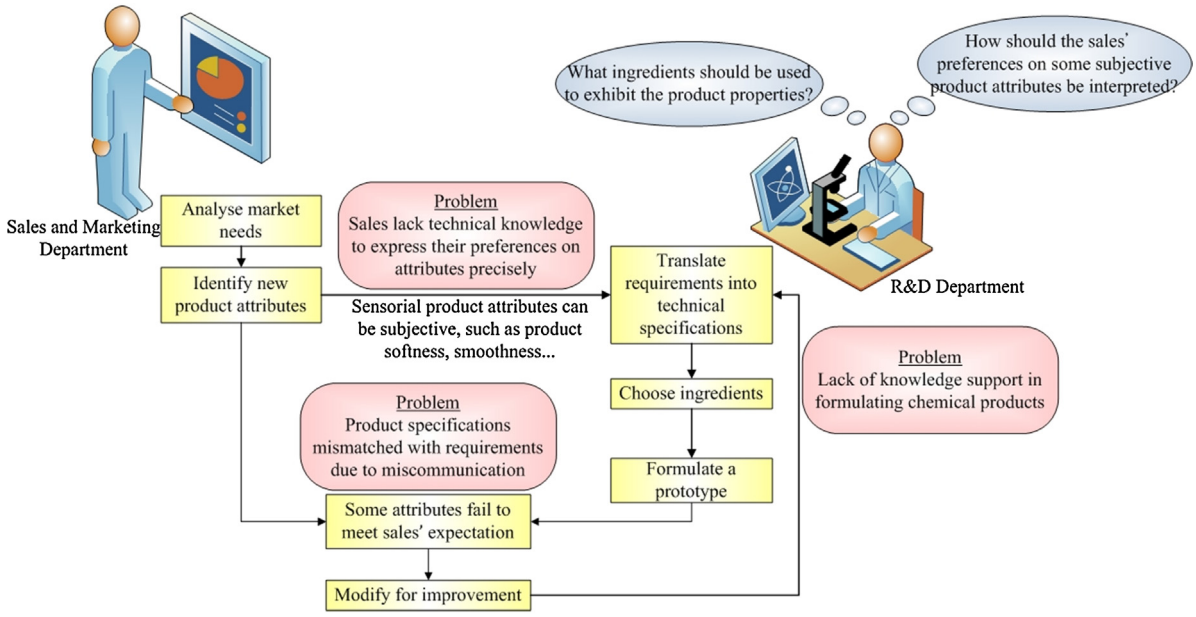

Fig. 1. Existing problems in chemical product development in the personal care industry.

In general, there are three types of NPD in the personal care industry.

(i) The first type involves new products which are initialized by the R&D Department. Formulators and chemists initialize this type of NPD when they are inspired by new chemical ingredients, suppliers or information from trade exhibitions, trade conferences, market reports and published papers. After a prototype is created, the R&D Department will present it to the Sales and Marketing Department. Since marketing is not greatly involved, the functions provided by KIFS may be of less importance to this type of NPD. Therefore, it is not the main focus of this paper.

(ii) The second type involves the development of new products which are targeted to a certain group of customers. Information for these kinds of new products is based on customer information. In usual practice, the Sales and Marketing Department creates product concepts such as "rejuvenating" and "refreshing", and the R&D Department then formulates products based on the given concepts. Panel evaluation is then required by having both departments judge how well the prototype fits the concept. In the evaluation, some subjective product attributes are involved and without any knowledge support tools, miscommunication problems between different departments can occur easily.

(iii) The third type is through reverse engineering in which some products from the markets or competitors are used as benchmarks. In this type of NPD, the Sales and Marketing Department will set some requirements on several subjective product attributes and the formulators and chemists have to interpret the meanings. For example, if the product used for benchmarking has a very smooth texture, the Sales and Marketing Department will require the prototype to have similar smoothness. If there are any misinterpretation, rework may be needed, lengthening the NPD cycle time.

As the focus in this study is to develop a system which can improve the communication between the Sales and Marketing Department and the R&D Department, the effectiveness of the KIFS is confined to the second and the third types of NPD. This paper is divided into six sections. Section 2 describes the past literature related to this study. Section 3 introduces the architecture of the KIFS. Section 4 contains a case study for demonstrating the feasibility of the system. Case study results and discussion of the system are presented in Section 5. Finally, a conclusion of this study is made in Section 6.

2. Literature review

Faced with a dynamic and turbulent environment that requires flexibility for the changing business needs, organizations are seeking ways to improve their new product development (NPD) so as to maintain substantial growth for business survival (Chan & Ip, 2011; Jang, Dickerson, & Hawley, 2005; Zahay, Griffin, & Fredericks, 2004; Zapata, Varma, & Reklaitis, 2008). An NPD process is a sequence of steps or activities that an organization employs to conceive, design and commercialize a product (Ayağ, 2005). Since most chemical-based products are formulated products containing different chemicals, active ingredients as well as additives (Conte & Gani, 2011; Mattei, Kontogeorgis, & Gani, 2012), its NPD process involves the generation and screening of a large number of chemical ingredients (Gani, 2004). The potential search space involved in the ingredient formulation process in chemical product development is large, constituting a significant portion of the entire NPD cycle time. A good formula is believed to be able to give a good compromise between different product properties (Claeys-Bruno, Lamant, Blasco, Phan-Tan-Luu, & Sergent, 2009). Ingredient formulation is usually undertaken through experimental trial-and-error techniques (Cheng et al., 2009; Conte, Gani, & Ng, 2011; Gani, 2004; Hill, 2009; Wibowo & Ng, 2004). This is a highly specialized task requiring a mix of skills from diverse disciplines to combine different chemical ingredients for creating the desired product properties (Conte, Gani, Cheng, & Ng, 2012). Without any knowledge support tools, chemical product development becomes iterative and time-consuming until an acceptable ingredient formula can be established. Since speeding up the product development is of paramount importance in enhancing competitiveness (Charpentier, 2009), the conventional approach is not generally appropriate for today's time-sensitive markets.