CARPET DEODORIZER & DISINFECTANT

Carrie Street and Justin Woody

Executive Summary

Carpet can serve as a haven for dust mites, mold, mildew, and bacteria. On average, one gram of dust includes 19,000 dust mites, which results in significant amounts of harmful fecal matter. Dust mites require a moist environment and humidity above 55% because they do not drink water but absorb it from the air. Dust mites' main food source is dead human skin cells. Humans shed about 1.5 grams of skin cells per day, aiding in dust mite growth and reproduction. Molds are microscopic fungi which mature rapidly and require moist areas and high humidity for growth. They produce an identifiable smell which can be overwhelming and, most importantly, produce health hazards, such as floating spores and even lethal mycotoxins. Bacteria produce butyric acid, which is known for a rancid butter or vomit smell. Shampooing carpets leaves up to 20% of the water in the carpet, creating the moist environment in which dust mites, mold, mildew, and bacteria thrive. A dry freshening and disinfecting powder product was designed to address the problems of dust mites, mold, mildew, and bacteria, as well as provide a long lasting fragrance. The product includes baking soda to absorb moisture, boric acid to serve as a disinfectant, and linalool (lily) fragrance in PLGA (polymer) particles to provide a long lasting scent. Baking soda is an all-purpose absorbent. Boric acid is a non-toxic insecticide effective against dust mites, fungus, mold, mildew, and bacteria. PLGA allows for the controlled release of linalool, a natural fragrance.

A utility function method allows for the quantification of consumer preference. In polls, consumers list product characteristics they consider essential and rank the characteristics in order of importance. The following consumer utilities were considered in the design of this product: disinfectant effectiveness, scent intensity, fragrance duration, toxicity, odor elimination, and scent type. The budget constraint for the price and demand model was found to be 54 million dollars from market analysis. Disinfectant effectiveness related the percentage of mites killed by the product to the amount of boric acid per unit area of carpet. A mass transfer model allowed for the relation of fragrance particle dimensions to the scent intensity, or concentration of linalool at a plane five feet above the carpet, and the fragrance duration. Consumer preference was greatest for a scent intensity between "Trace" and "Slight." Consumer preference increased with increasing fragrance duration; consumers preferred a product with an infrequent application requirement. The toxicity and odor elimination utilities allowed for the determination of the amount of boric acid and baking soda per unit area of carpet, respectively. The relationship between the toxicity and the amount of boric acid (the most toxic component of the product) per unit area of carpet was determined by examining the LD_{50} of boric acid versus various other chemicals. The relationship between the odor elimination and the amount of baking soda per unit area of carpet was determined by examining the odor elimination quality of existing products. Consumers preferred a lily scent when given a choice of lily, rose, and citrus scents. The production process involves preparation of the fragrance particles by double emulsion and mixing the fragrance particles with boric acid and baking soda.

Cost analysis and optimization were performed utilizing a price and demand model. For preliminary analysis, consumer awareness, diminishing marginal utility, and Borid 16 oz. product price were 0.9, 0.8, and $10.00, respectively, and remained constant throughout the analysis. Distribution center locations were chosen such that they were evenly distributed throughout the continental United States. The population and average humidity of each distribution center city were utilized to assign the relative amounts of production that would be sent to each distribution center. The optimum plant location was determined to be Oklahoma City, OK. The FCI (Fixed Capital Investment), working capital, and TCI (Total Capital Investment) were estimated to be $252,000; $126,000; and $378,000; respectively.

Maximizing the utility gave a product composed of 0.1% linalool, 0.2% PLGA, 20.06% boric acid, and 79.1% baking soda. With the utility maximized, the product could not be sold at any price to have a positive NPW (Net Present Worth). Maximizing the NPW gave a product composed of 0.01% linalool, 0.02% PLGA, 17.9% boric acid, and 80% baking soda. This composition resulted in a NPW of $1,730,000. Strauss plots and Monte Carlo simulations demonstrated that the NPW was most sensitive to changes in boric acid and baking soda prices.