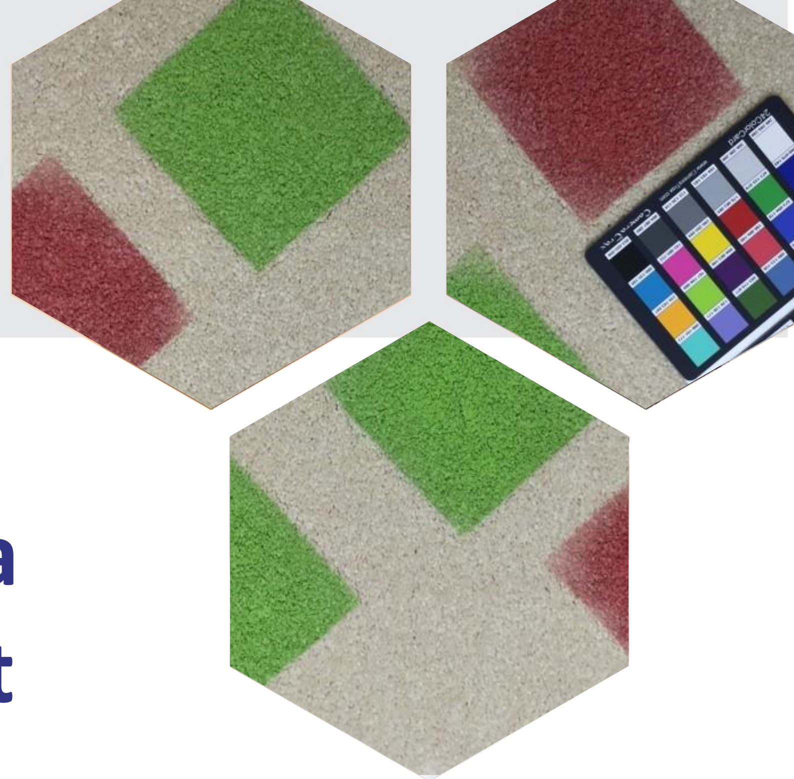
Cambridge Polymer Group



Formulation Development of a Carpet Treatment

By Dr. Stephen Spiegelberg

Summary

At first glance the relevance of material science in carpets is not obvious. However, recently a client came to CPG requesting that we develop a new post-install treatment for existing carpets. This deceptively simple request yields a host of analytical and material science challenges that captures, in one project, the diverse, multi-disciplinary nature of many of the projects we are involved in. In particular, this project covers the definition of performance requirements in a wholly new application, new formulation development and non-standard performance testing. This application note describes the formulation of a carpet treatment and the test methods developed to test the formulations.

Introduction

A client approached Cambridge Polymer Group with a request to develop a sprayable carpet treatment to refresh the appearance of faded carpets. This treatment would contain a choice of colorants, needed to be adherent to carpet fibers (especially older, abraded and soiled fibers), and be durable enough to handle normal foot traffic and vacuuming. And the treatment needed to be safe for consumers to apply.

Working with the client, numerical values were assigned to some of the specifications, where possible, so that success criteria could be established. Other specifications were more subjective, and some measurements were made to help guide formulation direction. These criteria were used to inform brainstorming material selection and the development of custom screening tests to aid in rapidly screening concepts and ideas.

Experimental

This project involved two teams at Cambridge Polymer Group: the material formulation team, and the test method team. The formulation team, comprised of polymer chemists, evaluated polymer systems that could be solvated in solvents that were:

1. Safe during application and in the home environment.
2. Suitably volatile so they would dry quickly.
3. Could be pigmented.
4. Could be formulated in sufficiently diluted concentrations so it could be sprayed.
5. Would be durable to foot traffic, vacuuming, and occasional surfactant-based wet cleaning.
6. Would be tolerant of varying carpet condition (brand new through to old, moderately worn)

7. Would wet polypropylene, nylon, and polyethylene terephthalate-based carpets.[1]

The concept utilized a plasticized low molecular weight resin to coat and "wet out" on the fiber carried in a volatile environmentally safe solvent. The formulation involved multiple resin and solvent combinations, along with stabilizers (UV), dispersants (for pigmented colorants), and propellants. Because of the large number of potential combinations, a design of experiment study was conducted to reduce the number of formulations that needed to be tested.

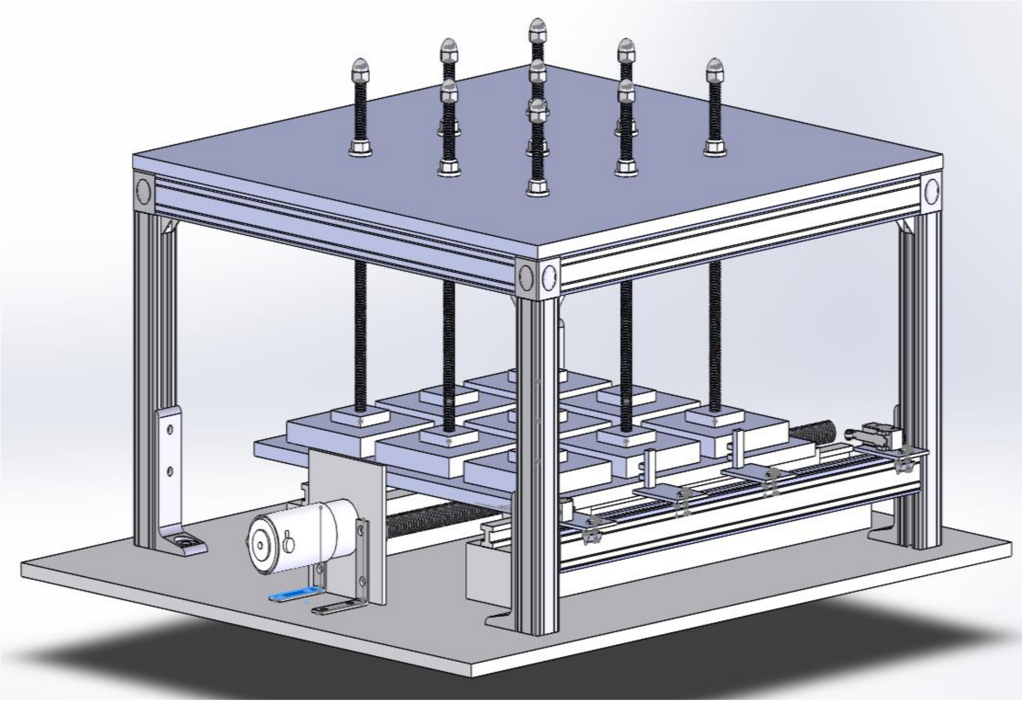


Figure 1: CPG developed a biaxial 9-station tread wear tester. Carpet pads with carpet treatment were placed under loaded counter-faces and were subjected to hundreds of thousands of sliding cycles, to mimic walking. Smearing or color fading was assessed optically.

Because of the unique nature of this request, standard test methods for determining the application efficacy and durability of carpet treatments were not readily available. As such, adjacent methods were modified, or new methods were developed in order to screen formulations. CPG developed the following screening tests:

1. Wettability testing by tensiometry
2. Wettability determination by scanning electron microscopy
3. Durability testing by ASTM D5252 (tumble drum tester for carpet pile)
4. Custom tread wear tester (see Figure 1)
5. Color density assessment (optical)
6. Vacuuming test
7. Real-time foot tread testing

[1] Wool and silk are also used in carpets, but these materials tend to be more durable, and the client determined that consumers using these materials are less likely to need to refresh the appearance of these carpets.

Results

CPG prepared dozens of formulations and ran them through the benchtop screening tests outlined above. Solvent selection was based on common solvents already used in households that presented no fire or health hazards. Formulations that showed poor sprayability or insufficient color density were excluded without further testing. Formulations that showed good sprayability and color density moved onto wettability testing to assess how the formulations wet nylon, polypropylene, and PET (see Figure 3). Some formulations were more suited for nylon, a more polar polymer, and some were better for polypropylene and PET, which are more apolar polymers. Good wettability resulted in the carpet treatment being drawn down the fibers, ensuring deeper coverage, which would aid in durability, color density, and would reduce the treatment forming a crust on the surface of the carpet.

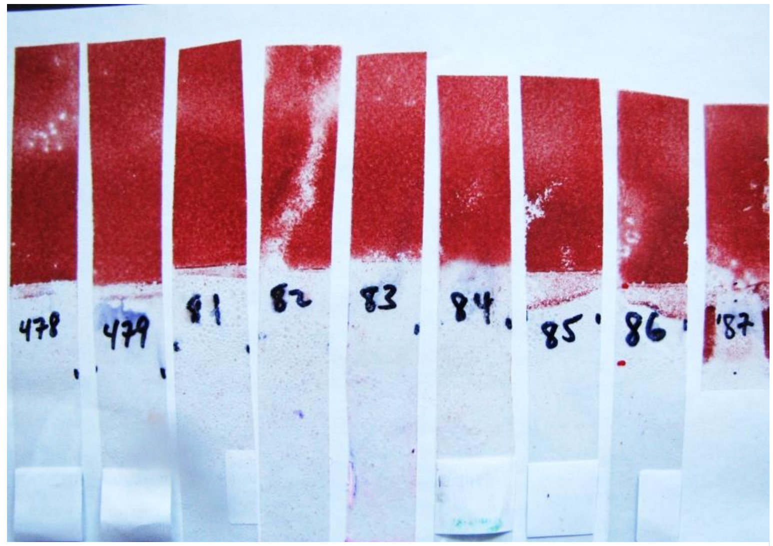


Figure 2: Color density test of 9 formulations sprayed onto exemplary PET substrates. Formulations 82, 85, 86, 87, and 478 had issues with sprayability.

Formulations that showed good wettability were then screened for durability in treadwear tests and cleaning tests. For real-time foot tread testing, test swatches were placed on the floors at CPG in high traffic areas for multiple weeks, and the visual appearance (smearing, color density loss) was assessed regularly.

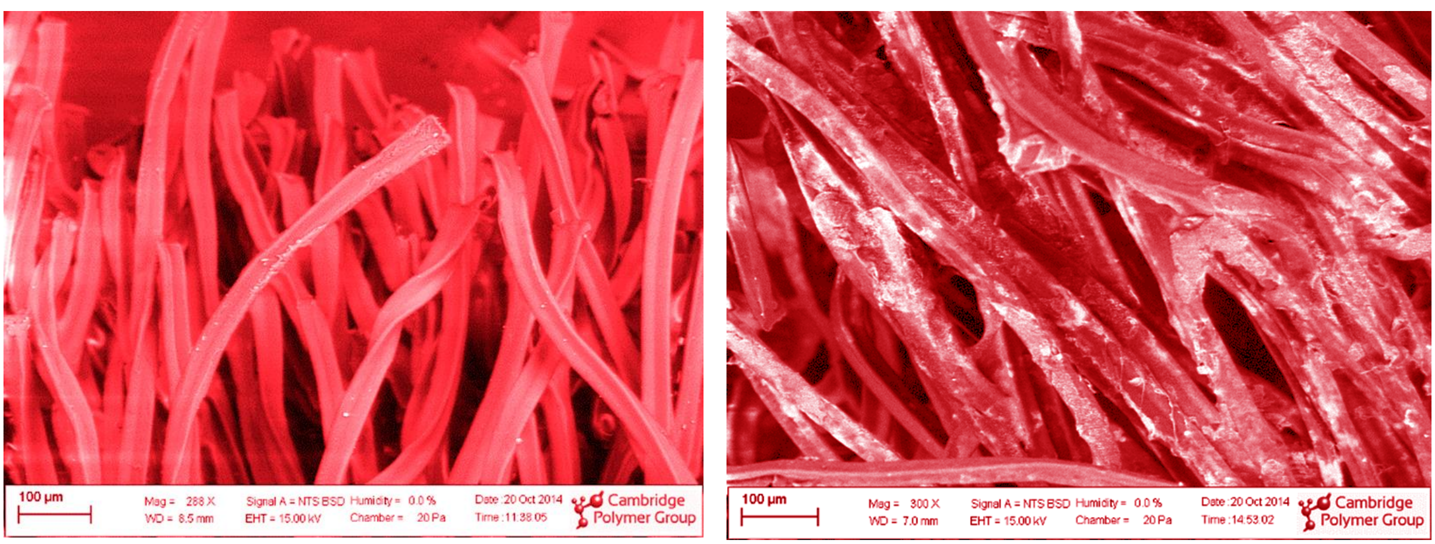


Figure 3: Scanning electron microscopy images of carpet fibers after spraying with test formulations. The sample on the left showed poor wettability, with little retained carpet fibers. The formulation on the right showed good wettability. The two formulations contained a pigment comprised of higher atomic number elements, so the SEM was conducted in back-scatter mode in order to easily identify the presence of the carpet treatment.

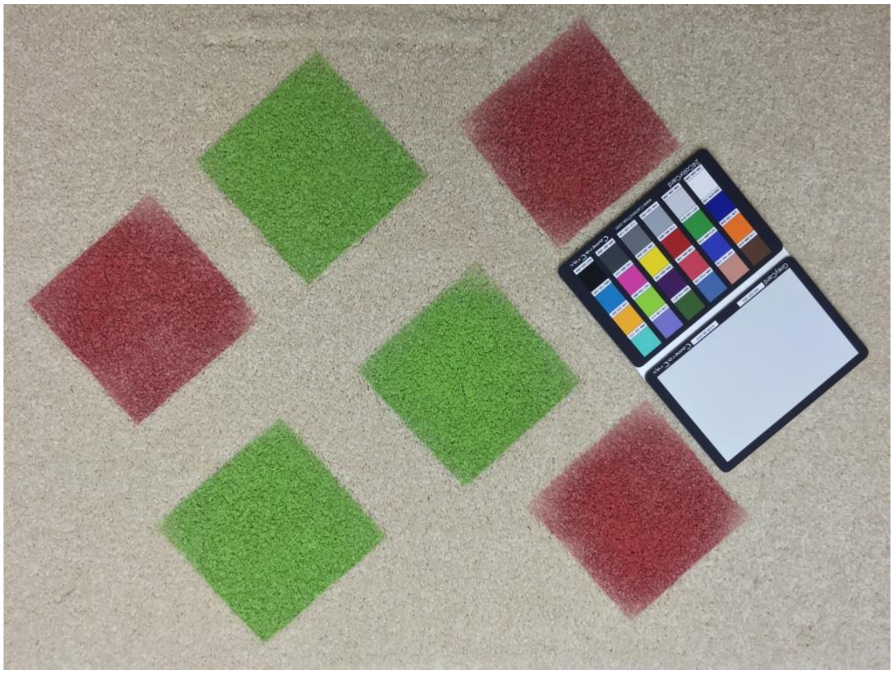


Figure 4: Example test swatches of formulations containing two pigments. These rectangular swatches were used for color density evaluation, wear testing (see Figure 1), and vacuum testing.

Conclusions

This project highlights the complex, multi-component nature of many real-world projects that CPG encounters. Although the basic ask was to generate a liquid coating for a polymer surface, the details of the request, and the competing needs of the end-user (the consumer in their home) add additional dimensions of complexity to the project. Nonetheless the basic tools and methods that are utilized here are applicable from industries as diverse as biomedical materials through to paint finishes on cars. At the end of this specific project, the client received three formulations that met their initial target properties and could be used for test panels where selected consumers could evaluate the materials in their own homes and provide feedback. The client also now has access to validated test methods for testing of future formulations.

References/Notes

[1] ASTM D5252 Standard Practice For The Operation Of The Hexapod Tumble Drum Tester (historic)

About Dr. Stephen Spiegelberg

Dr. Stephen Spiegelberg is the co-founder of Cambridge Polymer Group. With a career spanning over 25 years, Dr. Spiegelberg has consistently demonstrated an unwavering commitment to ensuring the safety and compatibility of medical devices and materials. At Cambridge Polymer Group, he directs a team of scientists performing contract research, analytical testing, failure analysis, and product development for the biomedical community and other fields. In 2022, ASTM International presented Spiegelberg with the Award of Merit, their highest recognition for distinguished service, for his contributions to the ASTM F04 Committee on Medical and Surgical Materials and Devices. He received his BS in Chemical Engineering from UW-Madison, and his Ph.D. in Chemical Engineering from the Massachusetts Institute of Technology.

For more information, contact us at
sales@campoly.com