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Material Evaluation of Air Vents

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Introduction

Two air vents were submitted to The Madison Group for material analysis. One air vent, signified by the label RRC-1, was a light grey in color (Figure 1). The other air vent, signified by the label RRC-2, was a darker color (Figure 2). No information was provided regarding the service life of the products. However, they appeared to have been placed in service prior to receiving the parts. The material comprising the air vents is unknown and will be undergoing investigation in this report.

Purpose

The focus of this project was the identification of the materials. This was to be accomplished using Fourier transform infrared spectroscopy (FTIR) and differential scanning calorimetry (DSC).

Conclusions

- It is the conclusion of this analysis that the two air vents showed differences.
- Sample RRC-1 was consistent with a polypropylene homopolymer material. There were no indications of additives or other constituents present within the material.
- Sample RRC-2 showed the material was comprised of polypropylene, along with additives within the material. Specifically, the base material was consistent with a polypropylene homopolymer. The results showed clear indications of calcium carbonate present in the material. Furthermore, there were signs of other additives within the material. These additives were consistent with being ethylene-based. Additional testing can be performed to investigate the filler level quantitatively, and the additives that were present within the material.

Tests and Results

Fourier Transform Infrared Spectroscopy

Samples of the two air vents were analyzed using Fourier transform infrared spectroscopy in the attenuated total reflectance (ATR) mode. Fourier transform infrared spectroscopy (FTIR) is a qualitative analysis technique for organic and inorganic samples that identifies chemical bonds in a molecule by producing an absorption spectrum. The obtained spectrum represents a profile of the sample; a distinctive molecular fingerprint that can be used for characterization and identification.

Sample RRC-1 showed absorption bands that were a strong match with polypropylene (Figure 3). No other distinct peaks were observed that indicated the presence of additional constituents within the material.

Sample RRC-2 also exhibited absorption bands that were characteristic of a polypropylene base resin (Figure 4). However, the spectrum of the RRC-2 showed additional bands. These bands were consistent with the presence of calcium carbonate filler within the material.

Differential Scanning Calorimetry

The two air vents were further analyzed using differential scanning calorimetery. Differential scanning calorimetry (DSC) is a thermoanalytical technique that measures temperatures and heat flows associated with thermal transitions in a material. The results are used to understand physical and chemical changes involving endothermic or exothermic reactions, or changes in heat capacity. A three-step program was employed whereby the sample was initially heated through melting, subsequently control cooled through recrystallization, and then reheated. The samples were cleaned prior to the analysis in order to remove surface residue.

Sample RRC-1 produced a relatively simple thermogram (Figure 5). During the initial heating of the sample, the material underwent a thermal transition at 165 ºC that was associated with the melting temperature of the polypropylene. Upon completion of the initial heating, the sample underwent a controlled cooling phase. During the controlled cooling phase, the sample exhibited an exothermic transition. This transition was attributed to the recrystallization of the material. Following the controlled heating and cooling through recrystallization, the second heating showed similar behavior to the initial heating. There were no signs of significant undercrystallization and/or gross contamination of the sample. Furthermore, there were no indications of other organic constituents within the material.

Sample RRC-2 showed multiple transitions through the initial heating and cooling phase (Figure 6). During heating of the material, the sample underwent a small endothermic transition at 82 ºC. This transition was consistent with a low concentration of an additive within the material. Specifically, this transition temperature could indicate the presence of an ethylene based additive such as poly(ethylene:vinyl acetate) (EVA) at relatively low concentration. However, further testing would be required to evaluate the additive present within the material. Following the initial transition, the sample went through the expected endothermic transition at 165 ºC that was associated with the melting temperature of the material. Upon completion of the initial heating, the controlled cooling resulted in two exothermic transitions that were associated with the recrystallization of the two constituents described above. The recrystallization temperature of 114 ºC was attributed to the polypropylene, while the recrystallization temperature of 72 ºC was characteristic of the additive. After the initial heating and cooling phase, the sample underwent a second controlled heating phase. During the second heating, the sample underwent a similar transition at 80 ºC that was attributed to an additive within the material. However, the second endothermic transition showed a slight bimodal behavior. This behavior was consistent with an additional constituent undergoing a thermal transition with the polypropylene base material. This constituent could be an additive present in the material. Furthermore, the temperature at which the transition occurs could indicate a high molecular weight ethylene additive. Additional testing would be required to evaluate any additives present within the material.

In addition to the differences in additives between the two materials, the two polypropylene base polymers showed variation in thermal behavior. Specifically, there was a difference in the recrystallization temperature. Sample RRC-1 underwent recrystallization at 124 ºC, while Sample RRC-2 showed a recrystallization temperature of 114 ºC. This difference exhibited was not consistent with expected lot-to-lot variation. When recrystallization occurs at a higher temperature, it will result in the formation of smaller crystals. Smaller crystal formation within the material will allow it to achieve a high crystallinity percentage. Therefore, it will take an increased amount of energy to melt Sample RRC-1. This phenomenon was observed as the heat of fusion of Sample RRC-1 was 78.48 J/g. Sample RRC-2 had a heat of fusion of 65.27 J/g.

If you have any questions concerning the contents of this report, please contact me. It should be noted that it is our policy to retain components and sample remnants for 60 days from August 9, 2017, after which time they may be discarded. If you would like to make alternate arrangements for disposition of the material, please let me know.

The results of this analysis have relied on information, material, and data provided by Aroplax Corporation. The findings reported here are based upon The Madison Group's current knowledge of the facts to date. The Madison Group, therefore, reserves its right to supplement, amend or modify its responses if new facts, evidence, or any other documentation is presented after this report is submitted. This information is presented in good faith, but no representation, guarantee, or warranty is made as to its accuracy, reliability, or completeness. In no event shall The Madison Group be liable for consequential, special, or indirect loss or any damages above the cost of the work.

Figure 1 – View of the grey colored air vent labeled as RRC-1.

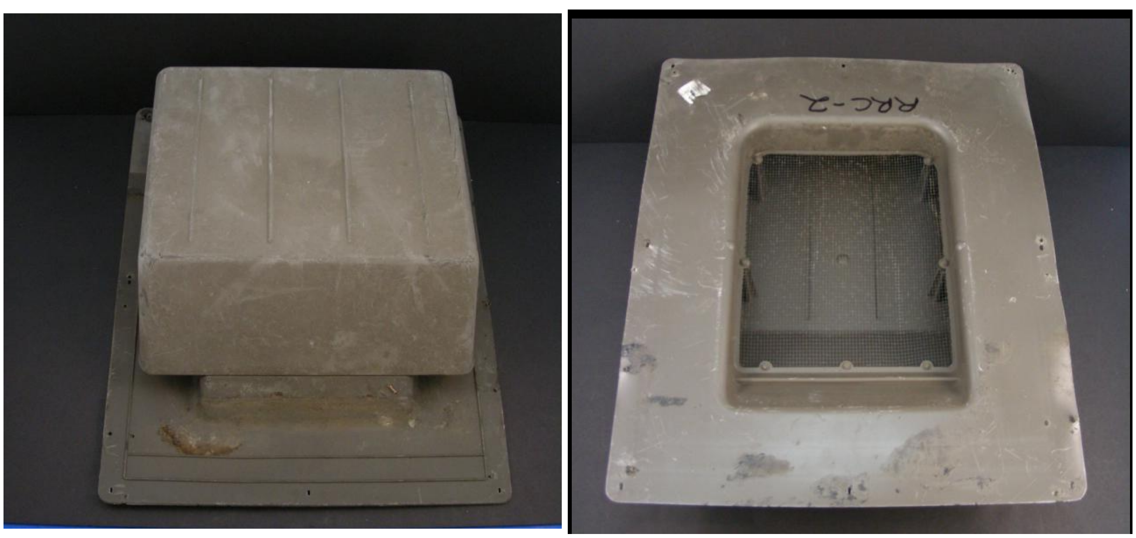


Figure 2 – View of the darker colored air vent labeled as RRC-2.

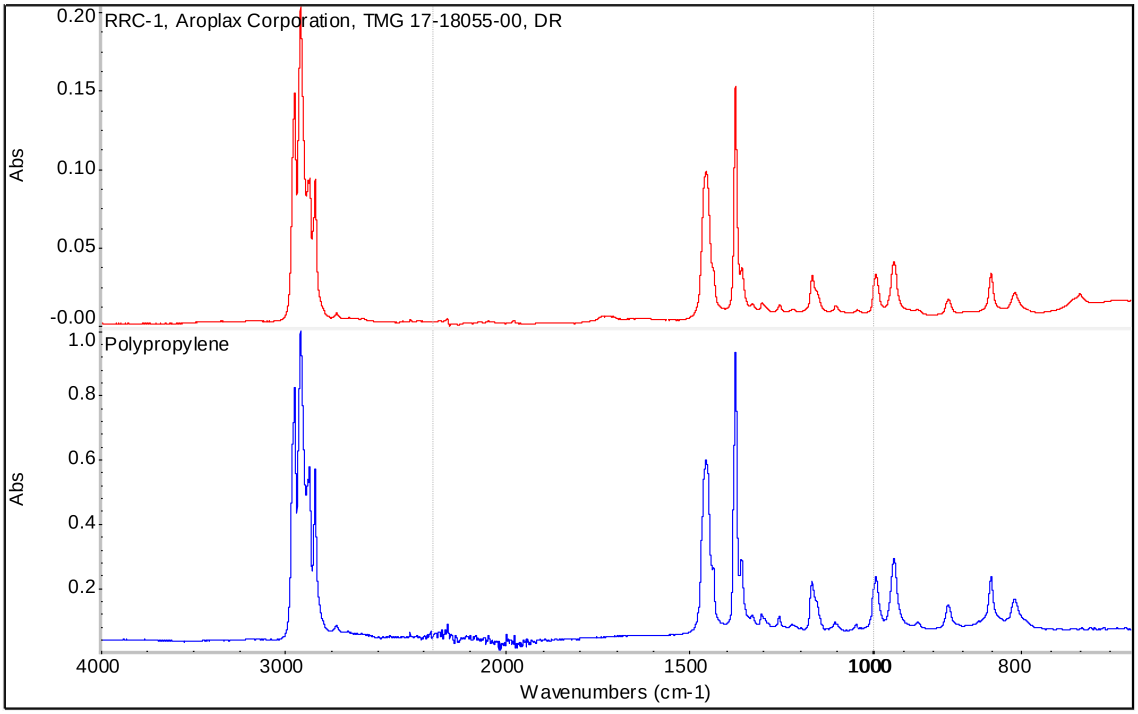


Figure 3 – FTIR spectrum of Sample RRC-1 showing absorption bands that were a strong match with polypropylene.

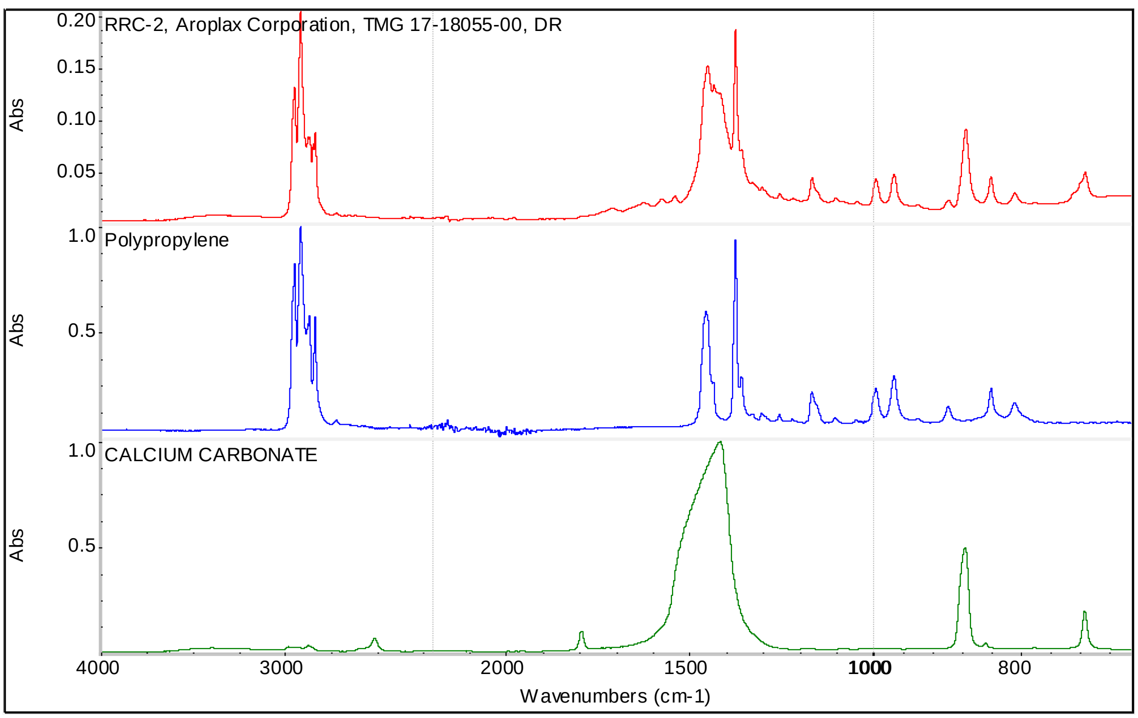
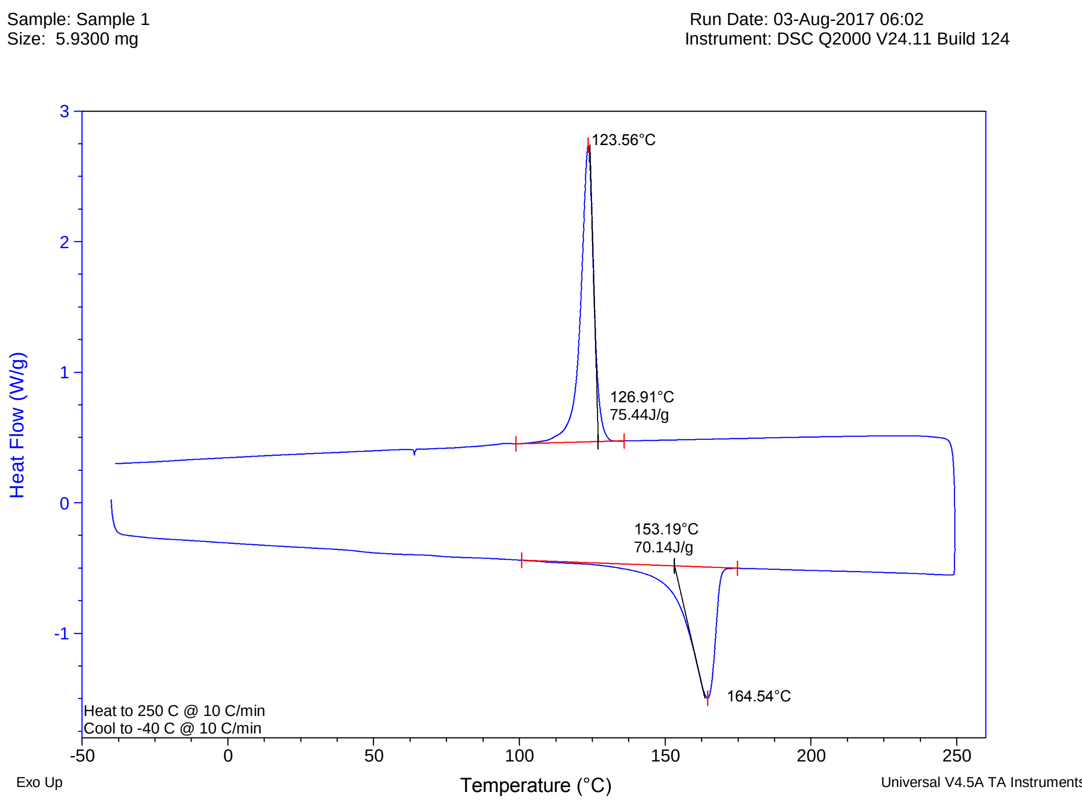


Figure 4 – FTIR spectrum of Sample RRC-2 showing absorption bands that were characteristic of polypropylene and calcium carbonate.



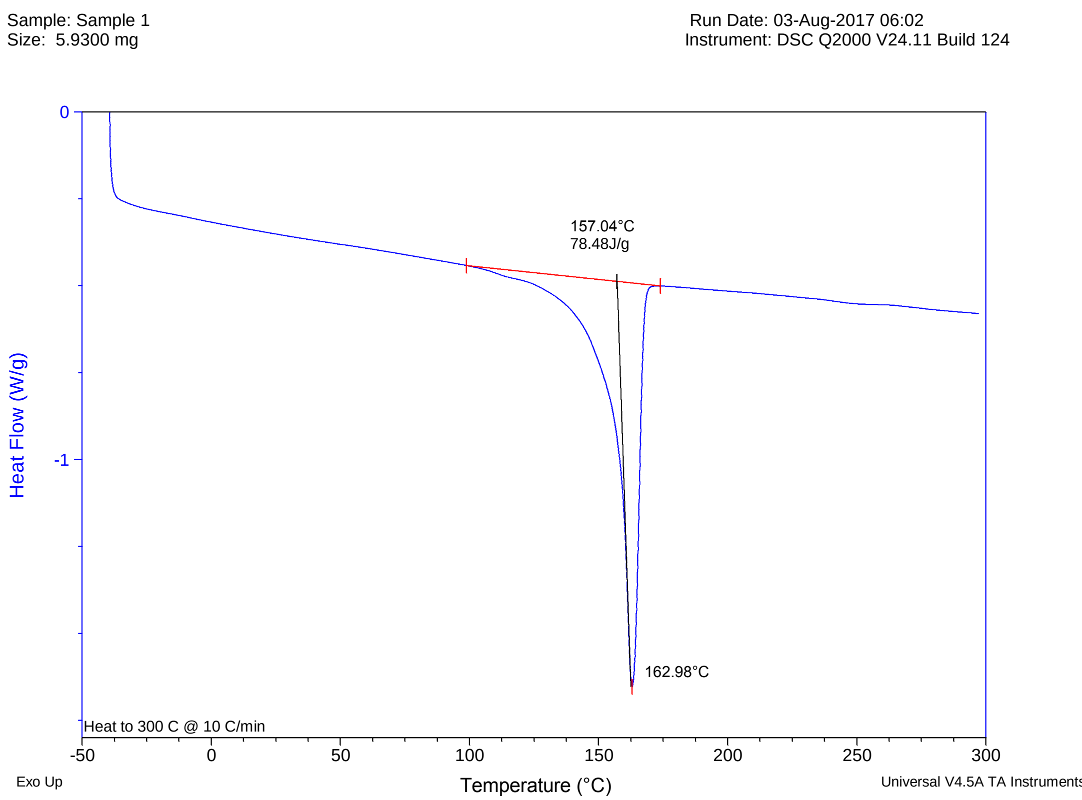
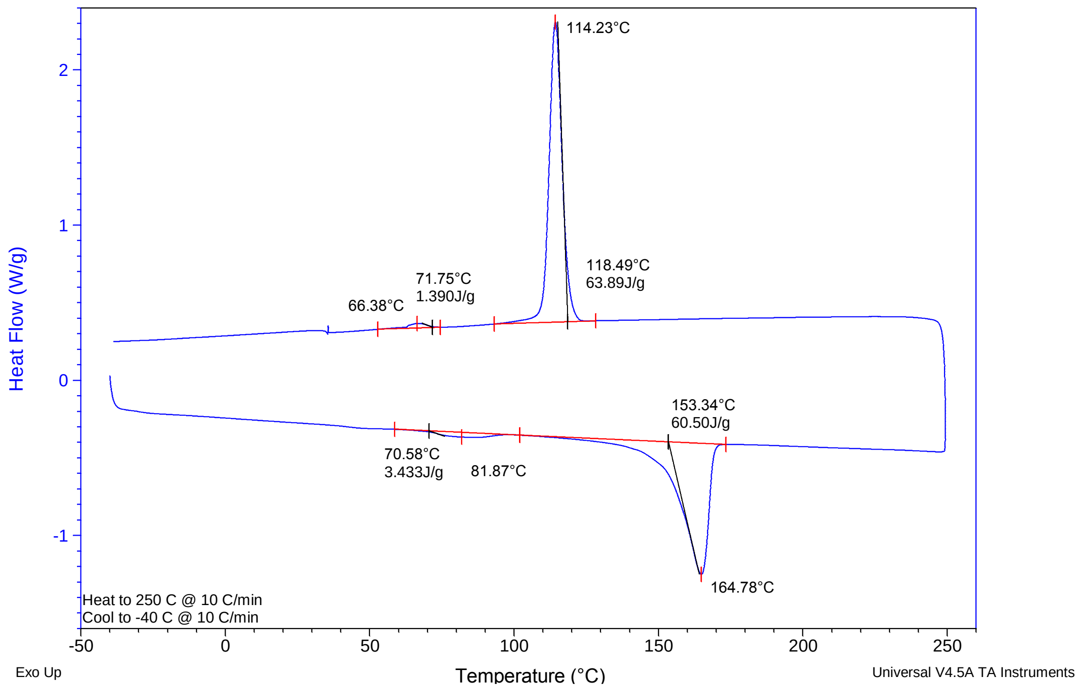


Figure 5 – DSC thermogram of Sample RRC-1 showing thermal transitions that were characteristic of polypropylene.

Sample: Sample 2 Run Date: 03-Aug-2017 07:45
Size: 5.5400 mg Instrument: DSC Q2000 V24.11 Build 124



Sample: Sample 2 Run Date: 03-Aug-2017 07:45
Size: 5.5400 mg Instrument: DSC Q2000 V24.11 Build 124

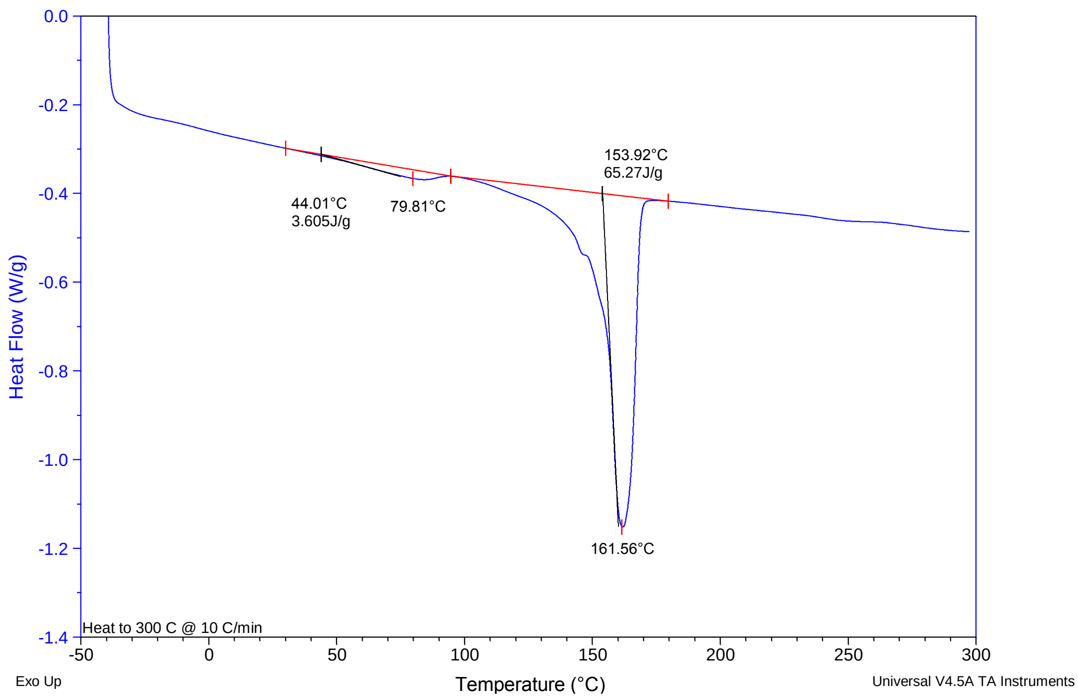


Figure 6 – DSC thermogram of Sample RRC-2 showing multiple transitions. The transitions were consistent with organic additives present in the polypropylene material. The transition temperature of 80 ºC was characteristic of an ethylene based additive such as EVA. Furthermore, a slight bimodal melting at 162 ºC was consistent with an additional additive within the polypropylene material.