



**A NEWLY DEVELOPED ANTIOXIDANT
PACKAGE WHOSE PERFORMANCE IS
UNAFFECTED BY THE PRESENCE OF
COPPER OR COLOR**



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A NEWLY DEVELOPED ANTIOXIDANT PACKAGE WHOSE PERFORMANCE IS UNAFFECTED BY THE PRESENCE OF COPPER OR COLOR

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ABSTRACT

Accelerated heat aging data generated from tensile tests at 165°C indicate that a newly developed antioxidant system for wire and cable compounds results in superior heat aging performance over current commonly used systems. The heat aging performance of Compound A, based on the new antioxidant system; is approximately twice as good as that of Compound B, which is based on a more commonly used system. In addition, data is presented which shows that the heat aging performance of Compound A is unaffected by the presence of copper and a black color concentrate. This may partly explain the superior performance of this new system over those that are currently used.

1. INTRODUCTION

Various pigments are commonly added to insulation compounds to make different color wiring. However, it is known that these chemicals can have an adverse effect on heat aging performance. While literature on the effect of color on wire and cable insulation performance exists, these are mostly limited to telecommunications cables and not to automotive wiring which is the subject of this paper [1]. Nonetheless, there is a general perception in the automotive industry that a relationship exists between color and heat aging performance. These relationships are difficult to generalize since the interactions tend to be pigment specific and depend strongly on factors such as the different metals that may be used in their formulation. For this reason, it is advisable to conduct experiments on any given system to accurately determine how a pigment will interact in a given compound.

The physical properties of the aged insulation material can also be greatly diminished in the presence of copper. This phenomenon, commonly known as copper poisoning occurs when the compound is extruded over copper conductors. This premature degradation is often attributed to the fact that copper ions catalyze the decomposition of hydroperoxides that are formed during aging, thereby supplying new radicals that further promote the aging process [2]. This effect of copper on the premature degradation of the insulation compound in most cases can be resolved by the use of metal deactivators [2, 3]. The ideal antioxidant system for wire insulation, therefore, will be one which is not susceptible to copper poisoning and is also unaffected by the presence of color concentrates.

In the present work, a newly developed automotive compound, which exhibits heat aging characteristics that are neither influenced by copper poisoning or the presence of a color concentrate (CC) is discussed. This is achieved by the use of a single antioxidant system as opposed to one that also contains a metal deactivator. The superior heat aging performance of the newly developed compound, A, is demonstrated by comparing its end of life heat aging behavior to that of a more standard compound, B. Both compounds have been developed for 125°C automotive under the hood wire and cable applications.

2. EXPERIMENTAL

Compounds A and B evaluated in the present work differ only in the antioxidant package used, with all other components such as the base resin and flame retardants being the same. Both are highly filled, non-halogenated, flame retardant peroxide cross linked polyethylene compounds formulated for low voltage 125 °C automotive wire and cable under the hood applications. For Compound A, the total additive package consists of a single commercially available primary antioxidant. Compound B contains two hindered phenols. No metal deactivators are used, and the total combined additive levels in both compounds is the same.

Copper powder is added to both compounds in order to simulate insulation performance in the presence of copper conductors. This is done in a Brabender mixer by producing a copper masterbatch (MB) of the compound as described in Table 1. The MB is then let down into the compound in order to efficiently disperse the 100 ppm of copper powder added.

The effect of color is investigated by mixing 1% by weight of a CC into the compound. Based on field observations and customer feedback, a black CC was selected for the present study. This color has been identified as being one of the most likely out of all the standard automotive colors to affect the heat ageing behavior of peroxide crosslinked polyethylene systems. All mixing is carried out in a Brabender at a temperature of 240 F for 3 minutes. No special precautions such as the use of a nitrogen blanket were employed during the production of the blends since the intention was to simulate as closely as possible, standard commercial mixing processes.

A non lead based carbon black filled colorant is used in the present work since the industry trend is a movement away from heavy metal based color systems. The colorant is commercially available from any major color supplier.

Once the compounds are produced as described in Table 1, they are cured at a temperature of 350 °F and a pressure of 40,000 psi for twenty minutes into 75 mil thick plaques. The plaques are then cut into Type IV dog bone specimens and heat aged in a circulating oven at a temperature of 165 °C until end of life, with specimens being pulled out for testing at regular intervals. Tensile testing is conducted in accordance with ASTM test method D790 as specified by the J1128 specifications developed for automotive wiring. This procedure was used, in place of the more controlled oxygen uptake methods since it represents the test procedures used in field qualification trials [2].

Table 1. Brabender MB and final compound formulations for incorporating copper and color.

Masterbatch & Components	Weight (%)	Weight (gm)	Cu (gm)	Cu (%)	CC (%)
MB	100	220	2.2	1.0	---
Compound	99	217.8	---	---	---
Cu Powder	1	2.2	2.2	100	---
Final Compound	100	220	0.022	0.01	0.01
Compound	98	215.6	---	---	---
MB made above	1	2.2	0.022	1.0	---
CC	1	2.2	---	---	100

3. RESULTS AND DISCUSSION

The effect of copper powder on the heat aging performance of Compound A is shown in Figure 1 where the tensile strength retention is plotted against time. A similar trend is obtained for the retention in elongation shown in Figure 2 for the same compound with and without the use of copper powder. Clearly, from both figures, it can be seen that the heat aging performance of Compound A is not significantly affected by the presence of copper powder.

Similar results are shown in Figures 3 and 4 for Compound B. The tensile strength and elongation results shown indicate that the heat aging performance of this compound is significantly affected by the presence of copper ions. Assuming that the useful life of the insulation is represented by at least an 80 % retention in tensile strength and a 50 % retention in elongation, as specified by the automotive J1128 specifications, the results indicate a 50 % drop in performance due to copper poisoning.

Figures 5 and 6 show the effect of color on the performance of Compound A. As shown, the black CC used in the present study does not adversely affect the heat aging performance of Compound A. The heat aging performance of Compound B on the other hand, is significantly affected by the presence of the black CC as shown in Figures 7 and 8.

The relative effects of color and copper on both compounds is shown in Figures 10 to 12 where the performance of each natural compound is compared to that containing either copper and/or color. From Figures 9 and 10, it is clear that heat aging performance of Compound A is unaffected even when copper and color are both present. However, for Compound B, as shown in Figures 11 and 12, copper and color do have an adverse effect on heat aging performance. In addition, copper appears to have a more profound effect on heat aging than the black CC used. This is shown in Figure 12 where the natural compound with copper performs as poorly as that which contains copper and black. Therefore, the presence of the black CC does not lead to a further drop in heat aging performance in the presence of copper ions.

From all the data presented, the overall performance of Compound A is significantly superior to that of Compound B, especially in the presence of both copper and color. As shown in Figures 10 and 12, failure as defined in the J1128 specifications occurs after approximately 30 days for Compound A as opposed to 12 days for Compound B.

4. CONCLUSIONS

Data is presented from accelerated heat aging tests which indicate that a newly developed antioxidant system for wire and cable compounds results in superior heat aging performance over current commonly used systems. In addition, the heat aging performance of the new system is unaffected by the presence of copper or black color concentrate. For the currently used antioxidant system, it is shown that the presence of copper and color, specifically the black colorant used in the present study, adversely affect heat aging behavior. However, the effect of copper is more profound.

5. ACKNOWLEDGEMENTS

The author would like to thank Mike Richardson and Chris Gulley for their invaluable help in preparing the test samples.

6. REFERENCES

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Figure 1. Effect of copper powder on the tensile strength retention of Compound A

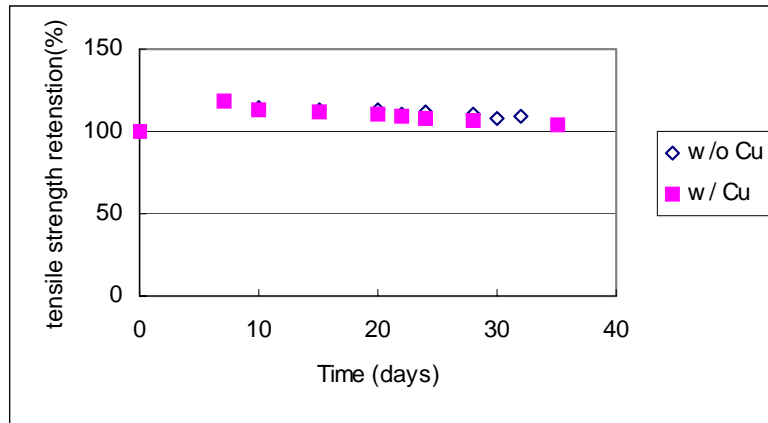


Figure 2. Effect of copper powder on the elongation retention of Compound A

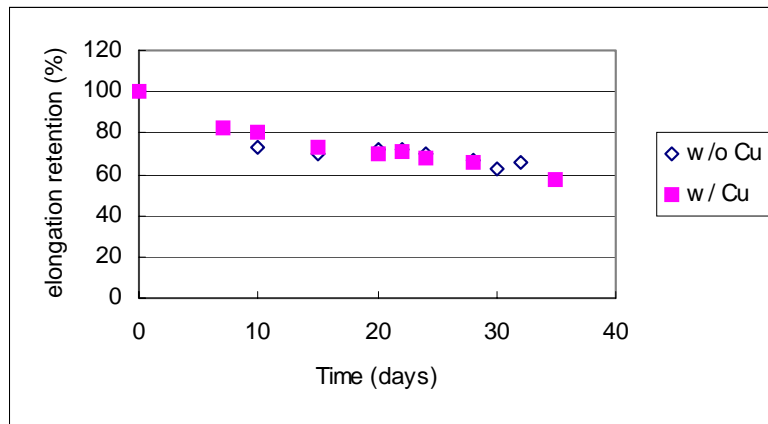


Figure 3. Effect of copper powder on the tensile strength retention of Compound B

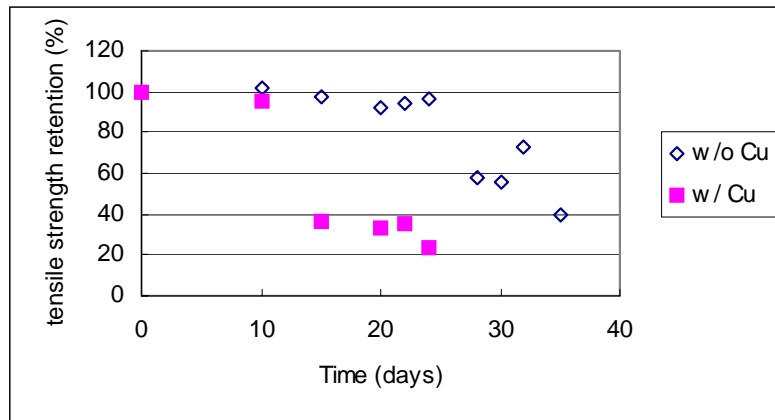


Figure 4. Effect of copper powder on the elongation retention of Compound B

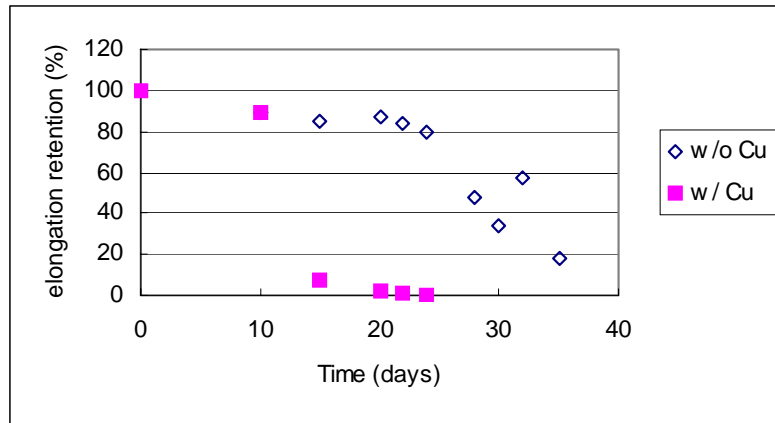


Figure 5. Effect of black color concentrate on the tensile strength retention of Compound A

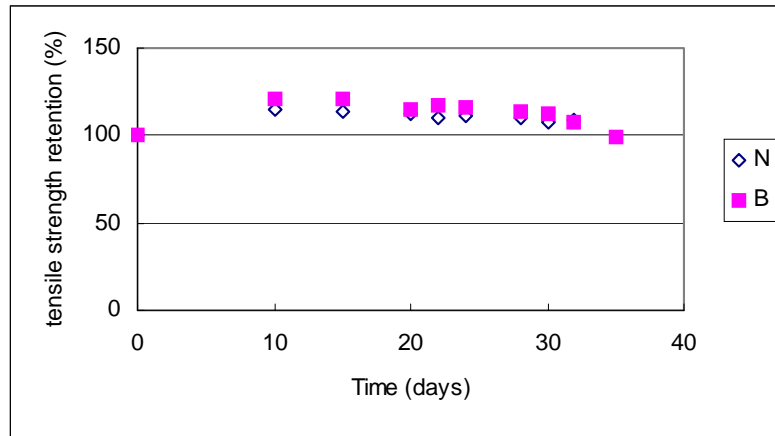


Figure 6. Effect of black color concentrate on the elongation retention of Compound A

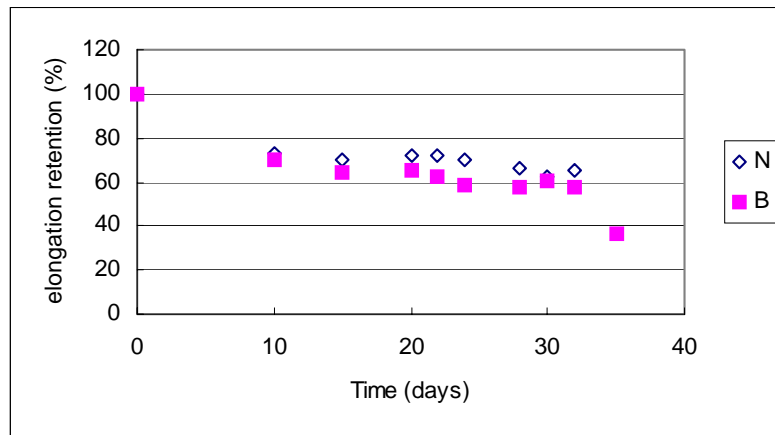


Figure 7. Effect of black color concentrate on the tensile strength retention of Compound B

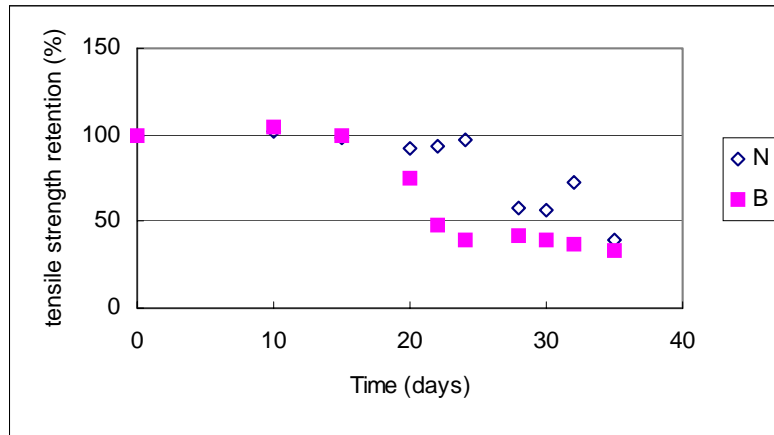


Figure 8. Effect of black color concentrate on the elongation retention of Compound B

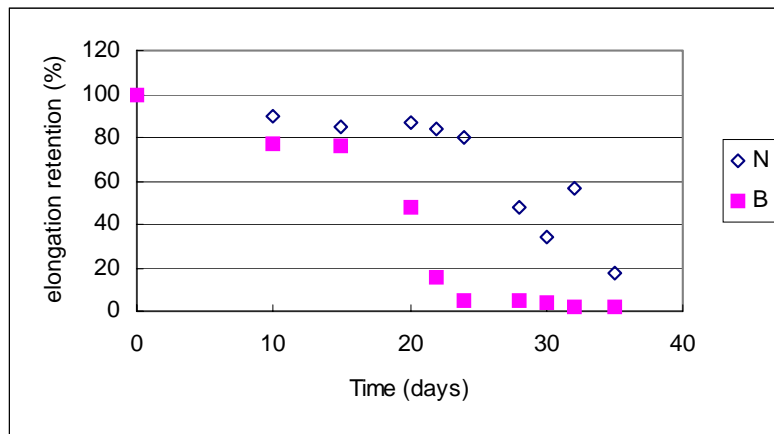


Figure 9. Effect of copper and black color concentrate on the tensile strength retention of Compound A

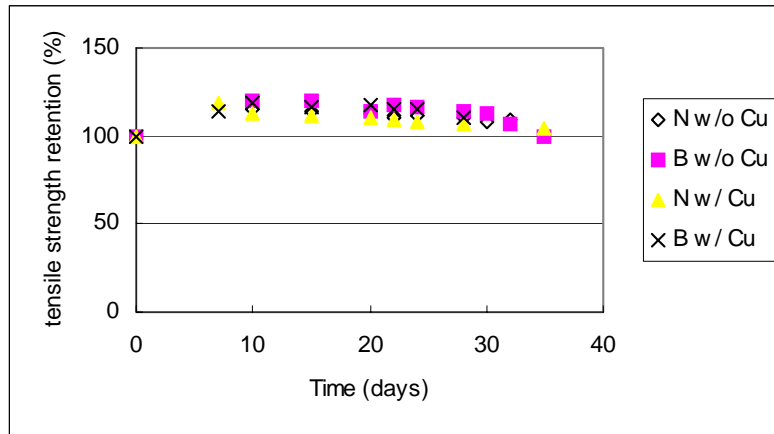


Figure 10. Effect of copper and black color concentrate on the elongation retention of Compound A

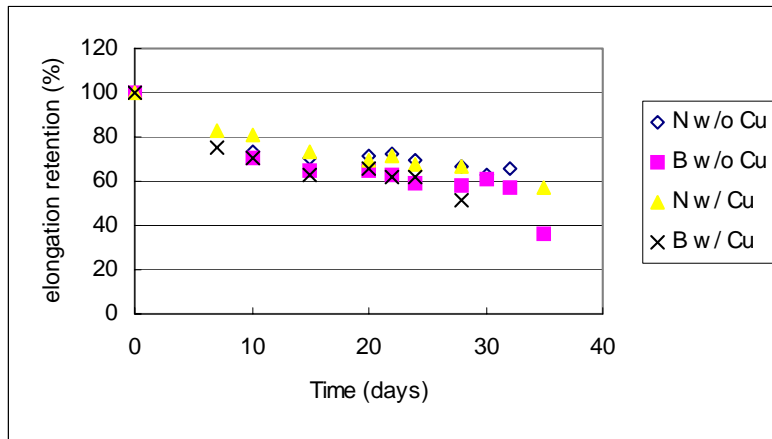


Figure 11. Effect of copper and black color concentrate on the tensile strength retention of Compound B

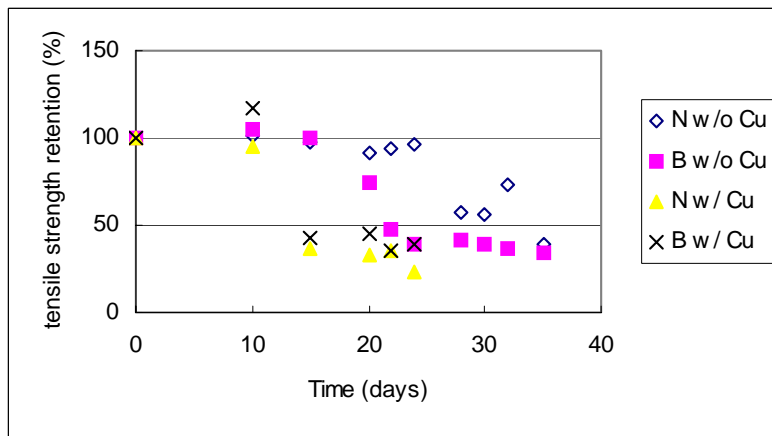
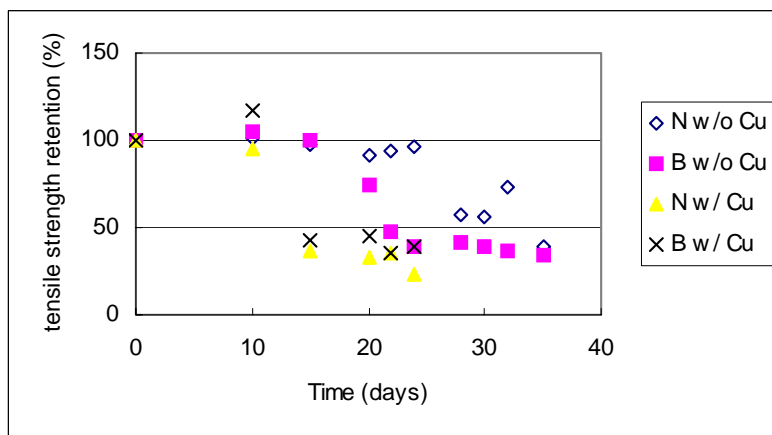


Figure 12. Effect of copper and black color concentrate on the elongation retention of Compound B





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