

ATTEMPT TO AFFECT THE APPARENT ¹⁴C AGE OF COTTON BY SCORCHING IN A CO₂ ENVIRONMENT

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ABSTRACT. One explanation for the radiocarbon dates on the Shroud of Turin being younger than the time of Christ is that the heat from a fire, which scorched a portion of the Shroud, may have affected the ¹⁴C content (dates) on the shroud by affecting molecular exchange between the fabric and atmospheric carbon. This report describes a laboratory test on the susceptibility of cellulose, in the form of cotton, to incorporate carbon from CO₂ while it is heated in a closed tube with carbon dioxide until the cotton considerably darkened. To maximize the effect of this hypothetical process, we simulated the shroud material with cotton that had a ¹⁴C level of 0.55 modern (55 pMC, equivalent to 4800 yr), and the atmosphere with pure CO₂, which had a ¹⁴C level of 1.3 modern (130 pMC). No measurable ¹⁴C transferred from the gas phase to the solid phase. The implication of this test is that scorching is an unlikely mechanism to affect the apparent age of cellulose-like material.

INTRODUCTION

Even before the accelerator mass spectrometry (AMS) dating of the Shroud of Turin (Damon *et al.* 1989), some people were concerned that fire or heat or scorching might affect the radiocarbon dating of textiles, allowing carbon from atmospheric CO₂ to become incorporated in the scorched portions, thus increasing the ¹⁴C level and reducing its apparent age. Only recently has a specific mechanism been proposed that might allow this to happen (Kouznetsov, Ivanov and Veletshy 1996). Jull, Donahue and Damon (1996), in response to Kouznetsov, Ivanov and Veletshy (1996), performed textile heating experiments that revealed no contamination effect. The work reported here was stimulated by discussions with Dr. Garmon Harbottle of the Chemistry Department at the Brookhaven National Laboratory (Upton, Long Island, New York). The experiments were performed in July of 1986, in anticipation of the actual dating of the Shroud, in order to allay any fears of problems with the Shroud dating, and dating of any scorched natural fabric material in general, which had been subjected to heating long after it grew.

METHODS

Materials consisted of cotton grown in 1984 during a United States Department of Agriculture (USDA) enhanced CO₂ experiment in an atmosphere rich in "dead" CO₂. The cotton was kindly donated by the USDA.

The present test was set up to optimize the contact of heated cotton with CO₂ of "post-bomb" ¹⁴C activity. The cotton was extracted five times overnight in the petroleum-based organic solvent xylene to remove oils that coat unprocessed cotton. Five grams of the cotton was cut with clean scissors into 8 samples, weighing from 0.55 to 0.78 g each. Split "A", weighing 0.68 g, was cut into 5 pieces; 0.35 g of this was placed into a 30-cm long, 9-mm outside diameter Pyrex[®] tube, taking up *ca.* 15 cm of its length. The tube was evacuated in a high-vacuum system, removing virtually all oxygen.

After evacuation, and while still on the vacuum line, CO₂ from combustion of the NIST oxalic acid ¹⁴C dating standard (OxII) was added to a pressure of *ca.* 300 mm. The tube was then sealed with a torch and removed from the vacuum line. Heating was performed with a Master Appliance Corp. Model HG 1301 12-amp heat gun. Different portions of the tube were heated until the enclosed cotton reached different degrees of darkness. The resulting colors ranged from black to light tan; one cotton plug remained uncharred. The total heating time was 15 min, 10 of which was spent on the darkest portion of the cotton samples. The temperature ranged up to 350°C. After cooling, the tube

was broken and the cotton was separated into four fractions according to their degree of scorching. Each fraction was analyzed for ^{14}C on the TAMS facility.

RESULTS AND CONCLUSION

The ^{14}C contents of the four cotton samples are shown below.

Lab no.	Appearance	pMC
A-4596	Darkest Sample, nearly black	0.551 ± 0.001
A-4597	"Dark toast" color	0.537 ± 0.014
A-4598	Light tan colored	0.554 ± 0.009
A-4599	Virtually no darkening	0.526 ± 0.009

Although A-4599 appears lower in ^{14}C than the others, its value is within 2σ of the average of the other three samples.

This heating test was unable to add measurable ^{14}C to the cotton. Based on this "worst scenario" attempt to affect the ^{14}C level in cotton during intense heating, it seems unlikely that the ^{14}C age of scorched linen or other cellulose (which may have burned long after the plant that produced it grew) would have been measurably affected by the scorching process.

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REFERENCES

- Damon, P. E., Donahue, D. J., Gore, B. H., Hathaway, A. L., Jull, A. J. T., Linick, T. W., Sercel, P. J., Toolin, L. J., Bronk, R. C., Hall, E. T., Hedges, R. E. M., Law, I. A., Perry, C., Bonani, G., Trumbore, S. and Wölfli, W. 1989 Radiocarbon dating of the Shroud of Turin. *Nature* 337: 611–615.
- Jull, A. J. T., Donahue, D. J. and Damon, P. E. 1996 Factors affecting the apparent radiocarbon age of textiles: A Comment on 'Effects of fires and biofractionation of carbon isotopes on results of radiocarbon dating of old textiles: The Shroud of Turin' by D. A. Kouznetsov, *et al. Journal of Archaeological Science* 23: 157–160.
- Kouznetsov, D. A., Ivanov, A. A. and Veletshy, P. R. 1996 Effects of fires and biofractionation of carbon isotopes on results of radiocarbon dating of old textiles: The Shroud of Turin. *Journal of Archaeological Science* 23: 109–121.