



Research Article

The Shroud of Turin's Improbable Body Image

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Abstract

If one were tasked with designing an image which is both maximally hard to explain, yet where the conservation of energy, momentum etc. are to operate as usual, the Turin Shroud's body image might well be the result. Peer reviewed explanations for the image that comport with the conservation laws include medieval manufacture, electrical corona and discoloration either by chemical reactions or on account of the decay of a radioactive isotope naturally present in linen. Based on the requirement that any creditable origination scenario must account for the microscopic characteristics of the body image, we argue that medieval manufacture and discoloration during a corona discharge are untenable. The former because of the inaccessibility of fibers buried in parent threads, the necessity of discoloring fibers all the way around their circumference to a precise depth, and finally because of the immense number of fibers involved. In the latter case it appears that the assertion that corona can penetrate linen producing an image with microscopic structure similar to that of the Shroud's is based on the misinterpretation of a photomicrograph. The alternatives, chemical reactions and radioactive decays, are improbable in the extreme. Chemical reactions, because of the large numbers of such reactions required to discolor a flax fiber running along a thread top and because fibers running on either side of discolored fibers are frequently entirely clear of discoloration. Disruption due to radioactive decays with the consequent formation of color centers along a fiber is also hugely improbable due to the extraordinarily long half-life of rubidium 87, a radioactive isotope found in the primary cell walls of plants.

Keywords

Turin Shroud, Body Image, Medieval Manufacture, Corona Discharge, Maillard Reactions, Rubidium Hypothesis

1. The Shroud's Body Image

The Shroud of Turin is a 1.1 meter by 4.4 meter rectangle of fine linen preserved in the Cathedral of John the Baptist in Turin Italy. The linen bears blood serum stains that record its use as a shroud [1] that enwrapped lengthwise the corpus of a scourged and crucified human male. Superimposed on dorsal and ventral views of these stains is a faint image of the corpus, the so-called body image.

Photomicrography during the 1978 STURP, (Shroud of Turin Research Project), revealed this body image to be a mono-

chromatic half-tone made from tiny straw-yellow discolorations against an otherwise pale-yellow background. Two to three hundred flax fibers, each having a diameter of only about 15 microns (15 thousandths of a millimeter), make up the Shroud's linen threads. Straw yellow discolorations were seen on fibers up to three layers deep inside their parent threads and these discolorations occurred only near thread crowns [2].

Three additional observations make explaining the body image extraordinarily difficult. First, fiber discolorations are confined to

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an outer one fifth of a micron thick cylindrical shell [3], the location of the fiber primary cell wall [4]. Second, with the exception of stray cosmic rays, no UV radiation or subatomic particles are observed to have penetrated thru fiber interiors [5]. Third, image density depends only on the number of discolored fibers visible per unit area [2]. Where the image density is approximately fifty percent, straw yellow and pale yellow fibers may alternate along a thread top producing *striations* [2].

The following four sections critique respectively the four origination hypotheses under consideration.

2. Medieval Manufacture

Using materials available to a medieval craftsperson, L. Garlaschelli [6] has fashioned a persuasive reproduction of the Shroud's body image. Viewed through a microscope however, Garlaschelli's image is seen to be made up of discrete discolored spots [6]. These were produced by etching with dilute sulfuric acid and do not combine to form linear discolorations running along the length of fibers as in the Shroud. Could a medieval craftsperson produce a more realistic micro-image, one that aligns with the fibers? The answer is no. Fibers must be discolored all the way around and to a uniform depth and many of these fibers are buried in threads. Finally, the number of fibers to be discolored in the ventral half of the Shroud alone exceeds ten million [7].

3. Corona Discharge

Corona is an electrical phenomenon which is best known for reducing the efficiency of high voltage AC (alternating current) power lines where the curved surfaces of metallic conductors experience alternately very high and very low electron densities [8].

In the case of the Shroud's body image the corona discharge hypothesis assumes a highly electrified corpus emitting corona that then discolors the Shroud. Papers in 2005 [9] and 2011 [10] supported this hypothesis with a photomicrograph, figure 22A in 2005, and figure 18(right) picturing the same photomicrograph in 2011. This photomicrograph shows an enlargement of a square millimeter of sugar impregnated linen [9] that had been exposed to corona at temperatures no greater than 63 °C [9] atop a plasma ball [11]. The discolorations present on the nine thread tops appearing in the photomicrograph are described as "... very similar to [those of] the TS [Turin Shroud] image ..." [9].

This, however, is not the case. The well-focused upper left portion of a photomicrograph of an area immediately above the corpus nose bridge [1] shows discolorations confined to the central portion of a thread top, while sharply curved portions where the thread dips to pass underneath crossing threads, are free of discoloration. This behavior is generally observed over the entirety of the body image [12]. On the other hand, the discolorations pictured in figures 22A and

18(right) reverse this. Here the flat middle part of the central thread top is entirely free of discolorations, while discoloration is now seen only where the thread curves downward. This reversal could be the result of caramelization that occurred when a 190 °C iron was applied to the sugar coated linen following its exposure to corona [9]. That pieces of caramel coated primary cell wall adhered to the iron is likely since the primary cell walls of flax fibers are not cemented to fiber interiors [13].

A recently published article "Coloring linens with excimer lasers to simulate the body image of the Turin Shroud," offers specious support to the corona discharge hypothesis [14] on the basis that both the laser and corona are emitters of UV (ultra violet) light. Conservation laws do not forbid this, however the UV intensity atop a toy plasma ball is not comparable to the vastly greater UV intensities produced by an excimer laser.

4. Discoloration by Chemical Reactions

In 2005 Rogers and Arnoldi [15] proposed discoloration by Maillard reactions between gases from a decomposing corpus and a superficial coating of pentose sugars that may have been originally present on the Shroud [1]. It was hoped that this could explain how information relative to the physiognomy of the corpus was transferred to the linen. Ray Rogers later questioned this hope in *A Chemist's Perspective on the Shroud of Turin* remarking that "... identification of a probable chemical process does not explain one of the most perplexing observations on the Shroud, the discontinuous distribution of the color on the topmost parts of the weave [1]."

But discoloration by Maillard reactions does have a small but finite probability. To appreciate this, consider the number of chemical reactions needed to produce an image saturation of fifty percent at a location where striations can be seen and where the Shroud was likely stretched above the corpus by a few millimeters. Such a location is pictured in a photomicrograph on page 14 of Rogers' book where a square millimeter of area immediately above the corpus' nose bridge is greatly magnified. In Rogers' scenario the relatively dense amino-bearing gases, cadaverine and putrescine, diffuse upward from the corpus experiencing random collisions with air molecules. The probability of their chemically reacting with a fiber slated to become straw-yellow, while missing fibers on either side that continue to retain their pale yellow color, is 0.5. Assuming a monolayer of pentose sugar molecules, each only a few ten thousandths of a micron in diameter, many millions of such lucky misses in a row are required to produce striations over a square millimeter of the body image. The overall probability for this to have happened is 0.5 raised to a power whose exponent is on the order of many millions. This is extremely small, but not quite zero.

5. Discoloration by Rubidium 87 Beta Decays

A recent paper [16] has shown that energetic electrons from

the radioactive decays of rubidium 87 could have sculpted the Turin Shroud's body image. Rubidium is present in sufficient quantities in linen fiber primary cell walls to do this *if most or all of the rubidium 87 nuclei present should happen to decay over a few days*. Because the half-life of this isotope is longer than the age of the universe [17], the probability for such an occurrence is, like that for discoloration via Maillard reactions, extremely small.

Radioactive decay proceeds independently of external stimuli, so in this case emanations from the corpus could not have communicated information about physiognomy to the rubidium 87 nuclei present. Surprisingly, the attendant decrease in the probability associated with image formation can be shown to be inconsequential in view of the already very much smaller probability that the timely rubidium decays should have occurred in the first place.

6. Discussion

Ray Rogers has lamented the paucity of funding in aid of a better understanding of the Shroud and its image [1]. In this regard, resources spent in support of the premise that a corporal body was converted into ultraviolet radiant energy [18] would for example have been better spent conducting tests that could potentially rule out image origination via chemical reactions or rubidium decays. This could be based on the observation that Shroud's body image does not fluoresce under UV irradiation while the background cloth and lightly scorched areas do [19].

Testing could proceed beginning with the acquisition of cellulosic samples ranging from hand fabricated linen to pure cellulose filter paper [1] and then checking to see whether the UV reflectivity of these samples is comparable with that of the Shroud's background linen [19]. Finally, UV reflectance measurements could again be obtained after application of a superficial coating of pentose sugars followed by exposure to a heavy amino-bearing gas following Rogers [1], or after irradiation from a collimated beam of energetic electrons following Saeman et al. [20].

Abbreviations

STURP	Shroud of Turin Research Project
UV	Ultraviolet

Author Contributions

James C Porter: Writing – original draft, Writing – review & editing

Conflicts of Interest

The author declares no conflicts of interest.

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