CALIFORNIA STATE SCIENCE FAIR
2002 PROJECT SUMMARY

Name(s)
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Project Number
S0105

Project Title
Down With Drag, Part Deux: Further Investigation into the Mechanism of Decreased Hydrodynamic Drag in Swimsuit Design

Abstract

Objectives/Goals
A velvety fine layer of air bubbles was previously observed to form on the surface of newer "elite" racing swimsuit fabrics. The object of this study was to investigate further and determine if a surface emulating a "microbubble" layer would have reduced hydrodynamic drag compared to other surfaces. I propose that the improved hydrodynamic performance of these swimsuit fabrics is actually the result of forming this coating layer of minute air bubbles.

Methods/Materials
A thin flow chamber (Hele-Shaw cell) was constructed out of two parallel plexiglass sheets separated by polyvinyl plastic spacers, and sealed aginst leakage using vaseline and binder clips. Water was channelled across the edge of polyvinyl plastic templates loaded into the chamber, and the flow rate at constant pressure was measured. Five templates were designed to simulate flow surfaces, including a "sawtooth" pattern mimicking the surface contour of the elite fabrics, a plain control, a "sine wave" pattern, an "irregular" pattern, and a "bubble-top" surface emulating the presence of a microbubble coating layer. Ten trials were conducted for each surface, and the cumulative results were statistically compared using T-testing with a level of significance at $P<0.01$.

Results
Water flow was significantly improved with the bubble-top surface, by +7.52 % compared to the plain control surface (7.00 +/- 0.04 ml/s vs. 6.51 +/- 0.27 ml/s, $P<0.001$). The sawtooth pattern (6.50 +/- 0.43 ml/s) as well as the sine wave design (6.50 +/- 0.15 ml/s) did not differ from control. The irregular surface had a trend toward lower flow/higher drag (6.30 +/- 0.41 ml/s), but this did not achieve statistical significance ($P>0.1$).

Conclusions/Discussion
A surface emulating a microbubble coating had improved flow compared to a control surface and other contours. I had previously observed that modern "elite" swimsuits became covered with a layer of minute air bubbles during immersion. This study supports my new proposal that the improved hydrodynamic qualities of elite swimsuits is imparted by the induction of a coating with microscopic air bubbles.

Summary Statement
This project tests the hydrodynamics influencing drag in swimsuit fabrics, and suggests that the actual mechanism by which elite fabrics reduce drag is by forming a coating layer of minute air bubbles.

Help Received
My father helped hold the apparatus steady while I conducted the flow measurements.