Interactions of Lipoproteins with a Polyurethane and a PEO-Modified Polyurethane (PEO-Modified Surface is Resistant to Proteins but not to Lipoproteins)

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Introduction: Lipoproteins (HDL, LDL, VLDL) are important major components of blood present in high concentration. Surprisingly, their role in blood-biomaterial interactions has been largely ignored. Lipoprotein particles consist of an outer phospholipid membrane or shell with protein components (apoproteins) also in the membrane. The particle core contains cholesterol and triglycerides. Apolipoprotein AI (apo AI) and apo AII are the major protein components of high density lipoprotein (HDL). Apo B is present in low density lipoprotein (LDL) and very low density lipoprotein (VLDL).

In previous work apo AI was identified as a major component of protein layers adsorbed from plasma to biomaterials having a wide range of surface properties [1], and quantitative data on the adsorption of apo AI to a biomedical grade polyurethane was reported [2]. The results from these studies suggested an important role for HDL in the interactions of blood with biomaterials.

The objective of the present work was to extend these investigations to other apolipoproteins and, most importantly, to the lipoprotein particles themselves.

Materials and Methods: Two materials were used: (1) a commercial biomedical polyurethane (Tecothane TT-1095A, Thermedics Polymer Products); (2) Tecothane containing 10% (w/w) of a polyurethane-polyethylene oxide triblock copolymer, PEO-PU-PEO. This material is referred to as "PEO". Proteins were radiolabeled with I-125, and adsorption experiments carried out in buffer solutions (pH 7.4) of the proteins under static conditions at room temperature. Quantity adsorbed was determined from radioactivity counts of the surfaces and solutions of known concentration. In some cases the adsorbed proteins were eluted and subjected to SDS-PAGE and immunoblotting. Surfaces were also analyzed with X-ray photoelectron spectroscopy (XPS) before and after exposure to the lipoproteins, with a specific focus on detection of phosphorus as an expected component of the lipoprotein particles.

Results and Discussion: Apo AI and apo AII were found to adsorb extensively to the Tecothane surface (Fig 1); in contrast only small amounts were adsorbed to the PEO surface. Significant amounts of apo B were adsorbed to the Tecothane surface (data not shown) and, as with apo AI and apo AII, much less adsorption of apo B was seen on the PEO surface (>90% reduction).

In contrast to the apolipoproteins, significant amounts of HDL, LDL, and VLDL were adsorbed to the PEO as well as to the Tecothane surface (Fig 2). Lipoprotein (HDL) adsorption on both surfaces was confirmed by immunoblotting and XPS (Fig 3).

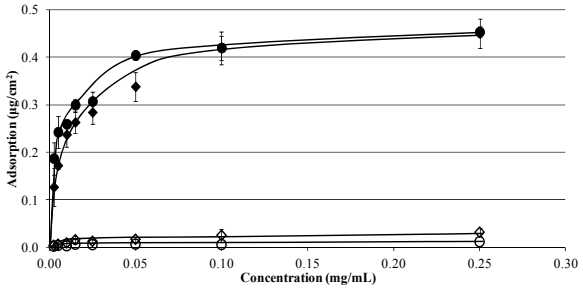

Figure 1: Apo AI and apo AII adsorption from buffer. (♦) ApoAI, Tecothane, (●) Apo AII, Tecothane, (◇) Apo AI, PEO, (○) ApoAII, PEO.

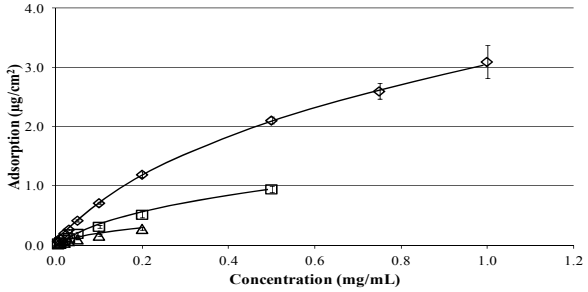

Figure 2: Lipoprotein adsorption from buffer to the PEO surface as a function of lipoprotein concentration (expressed in terms of protein content). (◇) HDL, (□) LDL, (△)VLDL.

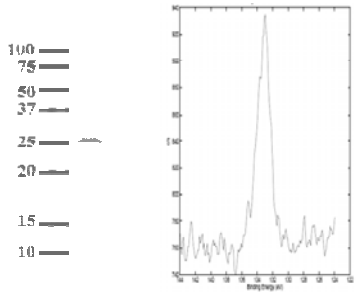

Figure 3: Immunoblot (anti-apo AI antibody) of protein eluted from PEO surface after exposure to HDL (left). Phosphorus 2p3/2 XPS of PEO surface after exposure to HDL (right).

Conclusions: Apo AI, AII, and B adsorbed extensively to the polyurethane surface, but not to the PEO-containing surface. In contrast the lipoproteins HDL, LDL, and VLDL adsorbed to the PEO surface as well as to the PU, suggesting that PEO is not resistant to the adsorption of lipoproteins, thus raising questions about its effectiveness as an antifouling agent on blood contacting surfaces.

References [1] Cornelius RM et al., Biomaterials 2002; 23: 3583-3587. [2] Cornelius RM et al., J Biomed Mater Res 2011; 99A: 109-115. [3] Tan J et al, J Biomed Mater Res 2008; 85A: 862-872.