# 载银多聚赖氨酸－海藻酸钠静电自组装多层膜修饰钛表面及其抗菌研究

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【摘　要】 **目的**　利用层层自组装技术在钛表面构建聚 L 赖氨酸 (PLL)- 海藻酸钠（ALG）多层膜，并在膜层中导入纳米银颗粒，以评价其杀菌效果。**方法**　利用层层自组装的方法将带正电荷的 PLL 与带负电荷的 ALG 在钛片上交替吸附沉积形成聚电解质多层膜，再用盐诱导相分离技术在多层膜中形成一定尺寸的微孔并在其中包裹纳米银粒子。扫描电子显微镜 (SEM) 、傅立叶红外光谱（FTIR）和能谱分析（EDX）对表面进行表征。并与变形链球菌共培养，观察对细菌的粘附和杀灭的作用。**结果**　SEM、FTIR 和 EDX 分析证实：多层膜成功沉积在钛片表面，并且纳米银粒子被包裹于其中。荧光显微镜显示纯钛表面有大量的活细菌，沉积聚电解质多层膜后细菌数量减少，导入纳米银离子之后附着于钛片上的细菌数量更少，并且随着膜层数的增多，银离子含量增加，抗菌效果也增强。SEM 结果与荧光结果一致。**结论**　通过层层自组装的方法在钛金属表面沉积载银 PLL-ALG 聚电解质多层膜，能抑制细菌的粘附。同时，随着膜层数的增加，银粒子含量增加，抗菌效果增强。

【关键词】 层层自组装　钛种植体　聚电解质多层膜　抗菌　纳米银
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## Study of the antibacterial effect of Ag-carrying polyelectrolyte multilayers (PEMs) on titanium surface

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【**Abstract**】 **Objective**　To evaluate the antibacterial effect of Ag-carrying polyelectrolyte multilayers (PEMs) assembled with PLL and ALG on titanium (Ti) surface. **Methods**　PEMs were prepared by layer-by-layer assembly with PLL and ALG. Silver nanoparticles were incorporated into the micropores in PEMs formed by salt-induced phase separation. Modified surface was characterized using SEM，FTIR，EDX. The antibacterial effect of modified surface was evaluated on *Streptococcus mutans*. **Results**　SEM，FTIR，EDX showed PEMs of PLL and ALG were successfully deposited on Ti surface，and silver nanoparticles were incorporated. Fluorescence microscopy revealed that there were a large number of live bacteria on bare Ti surface，fewer bacteria were present on PEMs，and the number of live bacteria was further reduced after nanoparticle incorporation. This antibacterial effect was further supported by SEM. **Conclusions**　Ag-carrying PLL/ALG polyelectrolyte multilayer films were deposited on titanium surface，and showed significant antibacterial activity. With the increasing of PEMs，silver content was increased，and antibacterial effect was enhanced.

【**Key words**】 Layer-by-Layer　Titanium implants　Polyelectrolyte multilayer films　Antibacteria　Nano-silver

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