Development and Characterization of Biomaterial Used in Urinary Catheter to Minimize Microbial Adherence

By

Hadeel Abdel all Abu Mahfouz

Supervisor

Dr. Ola Tarawneh

Co-Supervisor

Dr. Ahmad Deeb

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Abstract

Introduction: The employment of biomedical devices is undeniably increasing worldwide. However, the introduction of those biomedical devices (including urological catheters and stents) is restrained due to the development of urinary infections. Catheter-associated urinary tract infections (CAUTIs) are considered a prevalent type of nosocomial infection causing more than one million hospital admissions per annum. Additionally, these infections lead to severe critical health problems including kidney failure, bacteremia, and in severe cases mortality.

Aim: In this study we developed urological biomaterials from 2-HEMA and load the fabricated platform with antimicrobial agents namely rifampicin (RIF), cefixime trihydrate (CFX), and a combination mixture of both drugs to provide anti-fouling ability against bacterial infection and prevent encrustation.

Method: Determination of drugs solubility (RIF and CFX) in two different pH values (5 and 9) and at two different temperatures (20°C and 37°C). Evaluation of the antimicrobial activity was carried out against prevalent urinary tract infection pathogens. The dried hydrogels were prepared by free-radical polymerization of (2-hydroxyethyl methacrylate) (2-HEMA). FTIR was used to determine the interaction between p-HEMA and drugs. Characterization of the dried films involved the determination of glass transition temperature (T_g) using the dynamic mechanical thermal analyzer (DMTA). Determination of ultimate tensile strength, percentage of elongation%, and Young's modulus using TA texture analyzer. The ability of the dried films to absorb water was detected at two different pH values. Assessment of in vitro cytotoxicity using MTT test was tested on HEK cells. The persistence of antimicrobial activity (zones of inhibition) and determine the ability of biofilm formation was conducted on three different microbes.

Results: Solubility of both RIF and CFX increased at pH = 9 compared to pH 5. The antimicrobial activity showed additive action in using combined antimicrobial drugs. The FTIR spectra illustrated an increase in the O-H peak intensity and broadness in p-HEMA loaded with different ratios of drugs combination. T_g, ultimate tensile strength, and Young's modulus increased when mixed drugs were used, while the lowest T_g and highest elongation% was for p-HEMA loaded with RIF. The equilibrium water content (swelling) increased in pH = 9 in all hydrogel formulations where lower equilibrium water content for (3:1) RIF:CFX-loaded p-HEMA was observed. All p-HEMA hydrogel formulations were safe except RIF-loaded p-HEMA which showed a weak cytotoxicity effect. The persistence of antimicrobial activity (zones of inhibition) showed greater inhibition of bacterial growth in drugs combination. The best hydrogel formulations tested against *S. aureus* and *E.coli*

was (3:1) RIF:CFX-loaded p-HEMA, while against *P. aeruginosa* was (1:1) RIF:CFX-loaded p-HEMA. Mixed biofilm formation ability showed overgrowth and attachment of bacteria on p-HEMA surface. Also, the addition of antimicrobial agents reduced the mixed biofilm formation ability.

Conclusion: p-HEMA was successfully loaded with RIF, CFX, and drugs combination to decrease bacterial adhesion and biofilm formation ability. The dried hydrogel formulations showed acceptable mechanical properties and equilibrium water content. (3:1) RIF:CFX-loaded p-HEMA (F6) may be a good candidate for preventing bacterial growth, biofilm formation ability and has high safety to HEK cells. Thus, would be admitted for further improvement in terms of enhanced hydrogel flexibility.