

CHAPTER 4

CONCLUSION AND FURTHER PERSPECTIVES

The present work investigated surface modification of polystyrene (PS) Petri dishes by means of nitrogen-containing plasma processes. This work focused on two types of nitrogen-containing functional groups; nitrogen containing gas (N_2 and NH_3) and nitrogen-biomolecules (silk sericin protein).

In the first section, the surface properties of PS Petri dishes were successfully added with amino functional groups and increased hydrophilic properties from nitrogen- and ammonia-containing plasmas. The efficiency of cellular adhesion and proliferation of Wharton's jelly mesenchymal stem cells (WJMSCs) were significantly increased almost twice on the treated surfaces more than the commercialize PS petri dishes. Stability of active polar groups, including amine group on the PS surface was achieved by using the noble gas (He or Ar) mixed with N_2 and NH_3 . He plasma created stable covalent binding sites for attachment of active functional groups. The stability of a plasma treated surface was found via crosslink polymer using N-containing gas mixed with He gas more than Ar gas. Notwithstanding, the hydrophobic recovery of N-containing gas plasma treated surfaces over 30 days increased and had trend like untreated PS surface, including this cell culture system had to use animal serum (FBS) condition.

In the latter section aimed to overcome above mentioned drawbacks, we used nitrogen-biomolecules; silk sericin protein immobilized onto PS surface via a carbon-based intermediate layer. The effect of covalent linkage between sericin molecules and PS dish surface via a carbon-based film could slow down the release rate of protein into PBS solution. The carbon-modified PS dishes grafted with sericin had higher percentage of proliferated cells at day 7 more than the PS control coated with sericin when used in the condition of reduced FBS to 5% and serum-free system.

Present understanding of nitrogen-containing plasma modification of polystyrene petri dish can be summarized as the nitrogen- and oxygen-functional groups added from nitrogen gas and ammonia gas plasma are clearly the key factors to enhance WJMSCs attachment, proliferation and stemness stability. The efficiency of covalent linkage between carbon films-PS surface-sericin molecules could slow down the release rate of protein into solution and these PS-modified can be used in culture of human bone marrow mesenchymal stem cells (hBM-MSCs) with serum-free condition.

It can be stated that plasma processing of polymer surfaces in gases containing nitrogen exhibits important advantages over conventional wet-chemical processing;

- The efficiency of the functionalization can be controlled in a wide range

- For primary functional groups the selectivity can be controlled
- A large number of polymer types has been successfully modified by the same process
- Only a thin surface layer is modified, the bulk properties are maintained
- The surface is sterilized during the process
- Only small amounts of high-purity processing gases are required as reagents
- No aggressive solvents have to be handled

The relevance of the present work to related disciplines has been already applied to the following fields of active research.

- Polymer material research

Plasma surface modification by means of deposition of coatings by PECVD system can be changed the surface properties without altered the bulk properties. The means of deposition of coatings by plasma sputtering system can created the nanostructure surface onto polymeric material. Recently, plasma processing became an attractive medium for synthesis and modification of nanoparticles such as carbon nanotubes inorganic nanowire and others.

- Biomaterial research

Biomaterial research developed an advanced branch of adhesion science and aimed to investigate of the complex adhesion process of biological cells. Many cell types require adherence for good proliferation and cell culture development. Biomaterial research aims at controlling the adhesion behavior of selected cell types. In biological systems, amino groups are of special importance. Also the advanced polystyrene petri dish from this work can be as candidate for a new substrate for cell culture development.

Future research:

The complex interaction of the reactive species in the plasma and active biomolecules onto surface made it difficult to investigate their individual contribution to surface modification. It is important to study the depth of different detail by using XPS analysis. This could require the quantity of surface functional groups, especially the stability of treated functional groups during storage. In addition, the complex effects of sericin proteins (or other proteins) to MSCs's behavior have to investigate in more detail, and aims at applied in various types of MSCs and finally can used in human embryonic stem cell culture.