# Effect of nitrogen doping on properties of plasma polymerized poly (ethylene glycol) film

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**Abstract** : This study deals with the catalyst free radio frequency plasma assisted polymerization of ethylene glycol using nitrogen as reactive gas to modify the surface chemistry and morphology. The deposited film was characterized through various analysis techniques i.e. surface profilometry, Forier transform infrared spectroscopy, water contact angle and UV-visible spectroscopy to analyze film thickness, chemical structure, surface energy and optical properties respectively. The surface topography was analyzed by Atomic force microscopy. It was observed that the ethylene oxide behaviour and optical transmittance of the film were reduced with the introduction of nitrogen gas due to higher fragmentation of monomer. However the hydrophilic behavior of the film improved due to formation of new water loving functional groups suitable for biomedical applications.

## 1. Introduction

Synthetic polymers find diversity of applications due to numerous advantageous characteristics such as light weight, low cost and ease of processability. Most synthetic polymer materials used for biomedical applications reveal low biocompatibility. This is generally attributed to the surface chemistry and topographical aspects of substrate. A modification of surface chemistry seems to be a wonderful step to functionalize the material for biomedical applications.

Plasma polymerization has diverted the attention of people towards its versatility for production of thin films with manifold features. Being solvent free and low temperature process, the polymer films, from nano to micrometer thickness can be deposited irrespective of the substrate type. So plasma polymerization is an appealing method to be used for modification of materials to enhance its characteristics for manifold applications.

## 2. Experimental and results

### 2.1 Experimental

plasma polymerization was carried out in stainless steel chamber equipped with two parallel plate electrodes separated by 30 mm using radio frequency power via matching network. Prior to film preparation, chamber was cleaned by oxygen plasma and evacuated using dry pump to a base pressure of $1\times10^{-3}$ Torr. All experiments were performed at 70 mTorr working pressure that was maintained at constant value by a manual needle valve. Diethylene glycol dimethyl ether was heated and fed to reaction chamber. Pure nitrogen gas was used as reactive gas and supplied to the chamber separately.

표 1. 공정변수와 실험범위

| Deposition Parameters | Condition | Unit |
|---|---|---|
| Base pressure | $1\times10^{-3}$ | Torr |
| Work pressure | 0.07 | Torr |
| Plasma power | 100 | Watt |
| Ar flow | 40 | sccm |
| N2 flow | 20-50 | sccm |
| H2 flow | 5 | sccm |
| Substrate | glass, Si wafer | |

2.2 Results and discussion

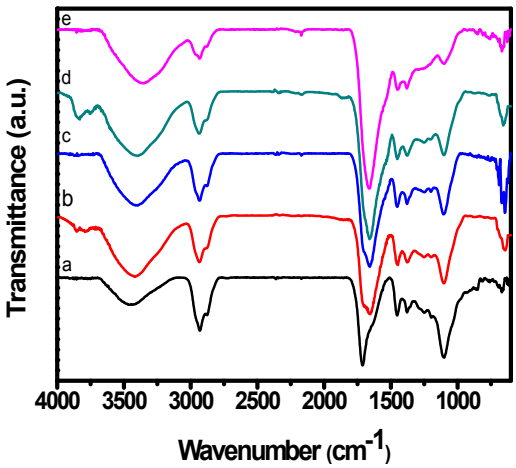


Fig 1. FT-IR analysis of film prepared using Ar only (a) and N2 (b, c, d, e)

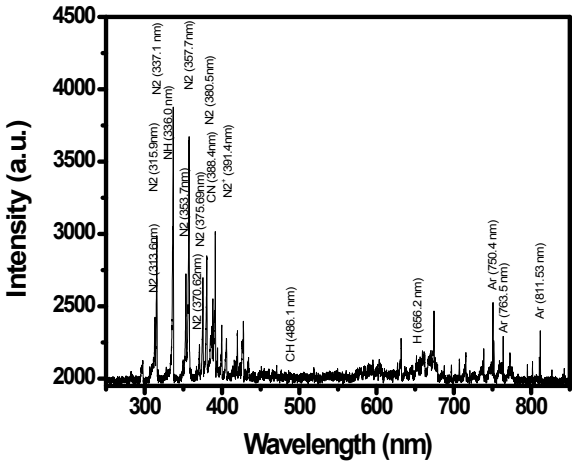


Fig 2. OES analysis of plasma containing monomer, Ar and N2 gases

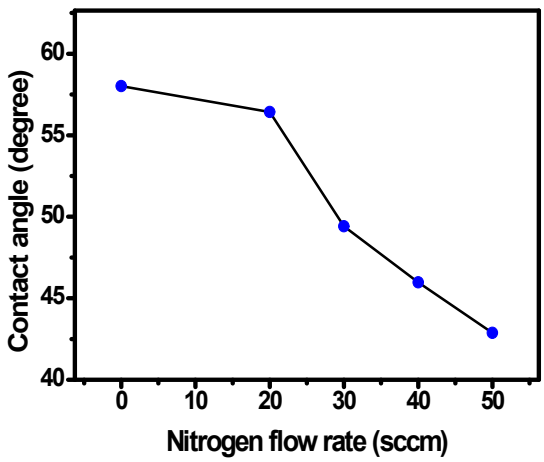


Fig 3. Water contact angle of polymer film at different N2 flow rates

Thickness of the film was controlled by profilometer throughout the film fabrication process. FTIR provided the proof of new functional groups introduced in the film. The absorption intensity of C-O-C bond at 1100 $cm^{-1}$ decreased with increasing N2 flow resulting in higher fragmentation of monomer. The absorption at 2900-3000 $cm^{-1}$ is attributed to CH functional groups and showed a decrement in intensity with nitrogen flow. Water contact angle analysis observations showed a rise in surface energy of film to improve the adhesion characteristics due to formation of new water loving amine and amide groups. Optical emission spectroscopy confirmed the presence and intensity of reactive species in discharge taking part in reaction to modify the chemical structure and functionalize the film.

## 3. Conclusion

It is concluded that new functional groups are introduced into poly (ethylene glycol) structure as a result of nitrogen flow which enhanced the film surface energy. polyethylene oxide character has a close relationship with nitrogen flow. A minute change in transmittance was observed after modification.

## References

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