# Fibre-optic pH sensor based on silver nanoparticles for Harsh Environments

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## INTRODUCTION

In the oil and gas industry, wells and pipelines suffer from internal corrosion problems due to the corrosive media. Corrosion may be caused by changing of fluid composition, pH, pressure and temperatures. Despite the availability of pH measurement techniques ambient conditions, it is challenging to measure accurate pH under harsh conditions of high temperature and pressure due to the instability of sensing materials [1-2].

**AIM:** In this project, a fibre optic pH sensor will be fabricated that is suitable for downhole condition at high temperature and pressure.

## OBJECTIVES

- To fabricate and characterize the surface plasmon resonance (SPR) pH sensor using coatings of silver nanoparticles on optical fibre which can function in harsh environments.
- To determine the optimum conditions for the synthesis of silver nanoparticles which are stable and decorate them on an optical fibre to form a pH sensor.
- To unveil the sensitivity and stability of the pH sensor in view of the particle size.

## METHODOLOGY

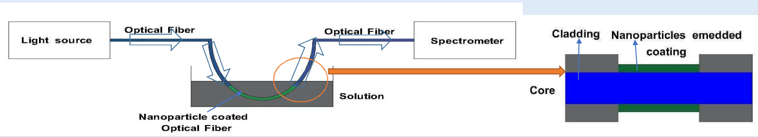


**Fig.1 :** Schematic illustration of pH sensing technique using optical fibre [4]

Nanomaterials exhibit very strong size-dependent localized surface plasmon resonance (LSPR) with the absorption maxima at a particular wavelength of light. The spectral position of LSPR is sensitive to the pH of its local environment [3-4], which can be used to fabricate a sensor.

**Characterization of Coating with silver nanoparticle**
Find out the coating having the best properties such as the presence of silver nanoparticle, uniform coating and lowest particle size.

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**Fabrication of fibre optic pH sensor**
The coating with the best properties will be considered for the fabrication of the pH sensor.

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**Verification of the sensitivity of the pH at room temperature against standard buffer**

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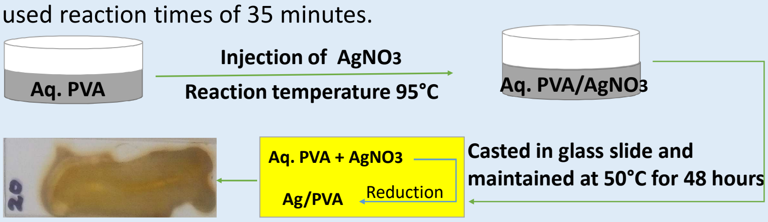
**Verification of the sensitivity of the pH sensor at higher temperature**

## EXPERIMENTS

For absorption spectra characterization, a number of samples were prepared by varying the concentration of $AgNO_3$ from 40 m mol/L to 50 m mol/L.

Polyvinyl alcohol (PVA), which serves as both stabilizing and reducing agent, was also used of from 4wt% to 5wt%.

For both sets of experiments a reaction temperature of 95°C was used reaction times of 35 minutes.




## RESULTS

**Table 1 : Summary of properties of Ag Nanoparticles**

| Sample No. and condition | Particle size (nm) | Peak Wavelength $\lambda_{max}$ (nm) | PWHM (nm) |
|---|---|---|---|
| (1) 40mM $AgNO_3$ & 4wt% PVA at 95°C with 25min reaction time | 73.2 ± 11.7 | 425 | 113 |
| (2) 40mM $AgNO_3$ & 4wt% PVA at 95°C with 35min reaction time | 44.7 ± 6.3 | 423 | 137 |
| (3) 40mM $AgNO_3$ & 5wt% PVA at 95°C with 30min reaction time | 35.5 ± 5.9 | 426 | 104 |
| (4) 50mM $AgNO_3$ & 5wt% PVA at 95°C with 15min reaction time | 35.1 ± 5.9 | 426 | 120 |

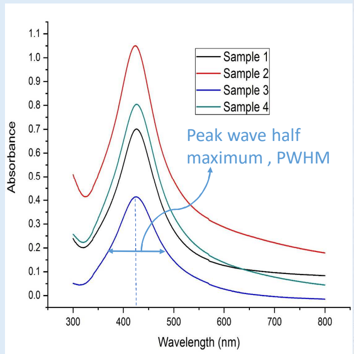



**Fig.2 :** Absorption spectrum of different sample

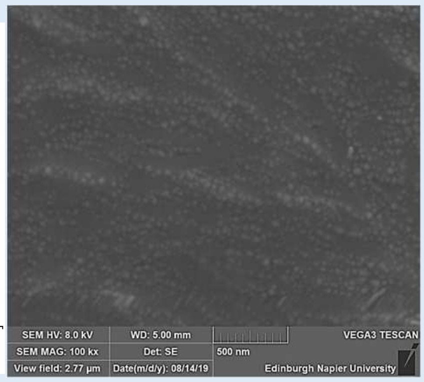



Fig.3 : SEM image for sample 4 silver nanoparticles embedded in PVA matrix

- The observed UV-VIS absorption spectra for different samples shows LSPR at different wavelengths.
- The absorption peak varies from 423 to 430nm for all the samples, showing the characteristic of SPR dedicated to silver nanoparticles.
- Sample 4 (Fig.3) shows non agglomerated, well uniformed dispersed and lowest particle size of Ag nanoparticles.

## CONCLUSIONS

In this study, the following conclusions could be drawn:
(i) UV-VIS spectrometry confirms the formation of Ag nanoparticles in PVA matrix by simple thermal treatment.
(ii) The wavelength of maximum absorption (λmax) derived from the absorption spectrum as well as the particle size of the Ag nanoparticles can be controlled by varying the heating time, concentration of metal salt and reducing agent.

## FUTURE WORK

- ✓ Investigate the ex-situ reduction of silver nitrate to silver nanoparticles in the PVA matrix.
- ✓ Compare the coating performance between in-situ and ex-situ reduction of PVA-encapsulated silver nanoparticles.
- ✓ Implementation of best coating of Silver nanoparticle on fibre optic and then investigate the sensitivity of pH sensor.

## REFEREENCES

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