# Design and Fabrication of Polymeric Nanostructures for Sensor Applications


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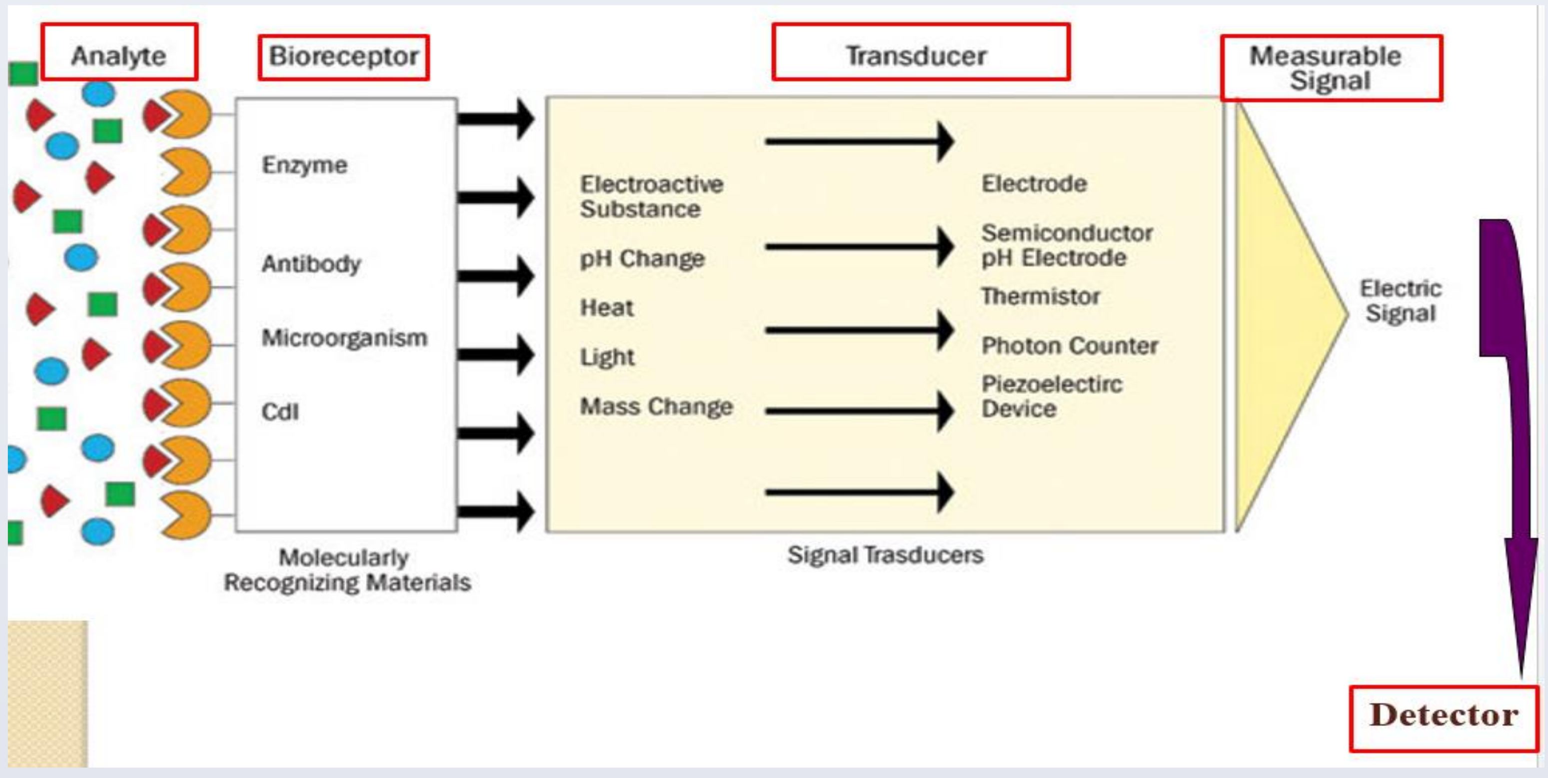
## Introduction

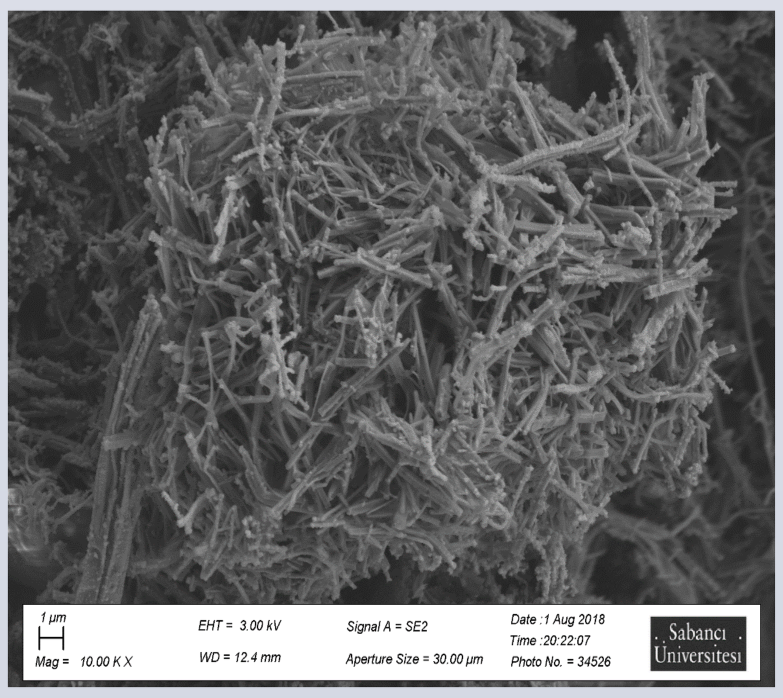
Glucose is one of the carbon hydrate in living organisms which is the main energy source. Its concentration in human body can be higher than the expected range. This causes metabolic diseases such as diabetes. In this project, we aimed to develop a biosensor which can detect glucose. Biosensors are devices that convert biological response into an electrical signal. Biosensors differ to the measurement techniques and are named according to these techniques; amperometric, potentiometric, thermal, piezoelectric, optic biosensors. Biosensors are composed of receptors and transducers. Enzymes and antibodies are widely used as a receptor. Transducers differs according to changes in NADH concentration, pH, conductivity, temperature, mass or absorption. In detection of glucose, amperometric enzyme electrodes based on glucose oxidase are used in this project. A amperometric biosensor has a particular characteristic that is the kinetic of electron transfer between activated part of the immobilized enzyme and surface of the proper potential electrode. High sensitivity and fast response are the important characteristic of amperometric biosensor and these features are maintained with fast electron transfer from biocomponent to electrode (Ozyurt, 2014). In order to provide high electrical conductivity, we preferred conductive polymers. Conductive polymers have been used in many applications such as sensors, biosensors, packaging, transistors, batteries and so on. We preferred to use poly pyrrole which possesses high conductivity with high efficiency and low cost.

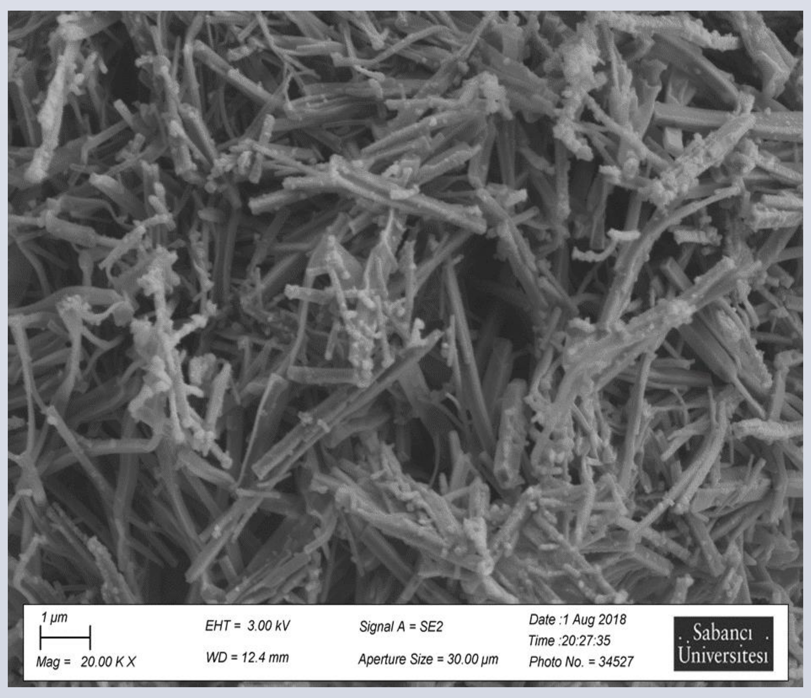



(AG Scientific, 2016)

## Polypyrrole Nanotubes

Polypyrrole is one of the polymers that has high conductivity and good environmental stability. Therefore, it allows us to use it in circuit parts for energy conversion, storage and target detecting purposes with low-cost and high efficiency. The main reason why polypyrrole is used in this project is its intriguing nanoscale morphology and lowest resistance value among the other conductive polymers. One of the other advantages of polypyrrole is its biocompatibility. Since in this project a microfluid glucose biosensor production is aimed, usage of biocompatible materials is fundamental. In this project, polypyrrole nanotubes are used as a target interacting, detecting part of the sensor mechanism. First goal was the producing conductive nanotubes since they are the part that has changing conductance as the target, glucose, is detected. To detect glucose, our aim was, after producing polypyrrole nanotubes, an enzyme, glucose oxidase, is adsorbed to the nanotubes. After that, glucose oxidase adsorbed nanotubes are used in coating the surface of electrodes. Then, as glucose is detected it reacts with enzyme coated nanotubes and it creates a resistance change and results in a response.





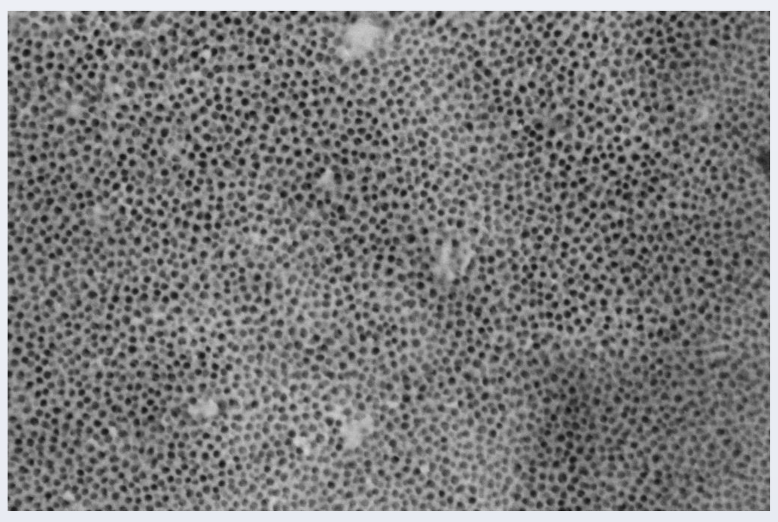
In this project, to produce conductive nanotubes iron (III) chloride, methyl orange and polypyrrole is used. Methyl orange is used as a structure-directing dye, iron (III) chloride as an oxidant and polypyrrole as a conducting polymer (J. Mater. Chem. C, 2017).

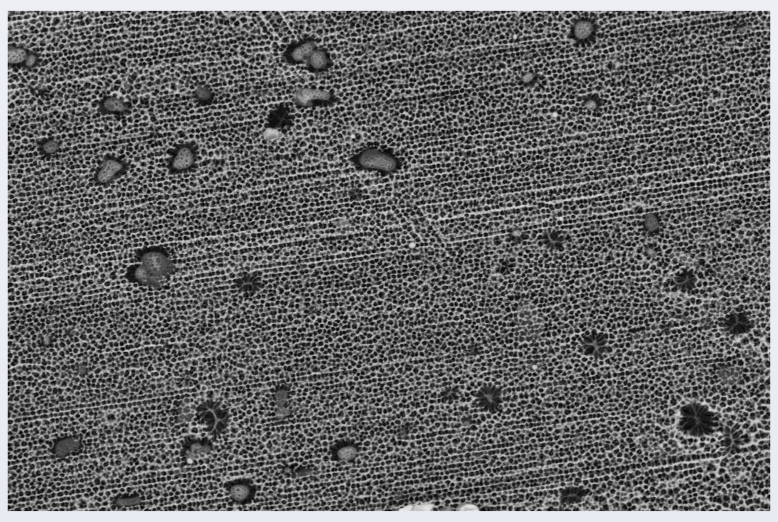
In our experiments, we started with dissolving $FeCl_3$ in distilled water. Secondly, methyl orange is put into the solution. Then, polypyrrole is added. After that, solution is put to the stirrer for 24-36h at 500rpm, and black powder which are poly pyrrole nanotubes are obtained. In the following step, solutions are put into the falcon tubes and centrifuged at 5000 rpm and twelve minutes for three times. Finally, 30ml of ethanol is added to almost dry powder and put into the heater for twelve hours at 75 degrees celsius to get dry and deionized nanotubes.

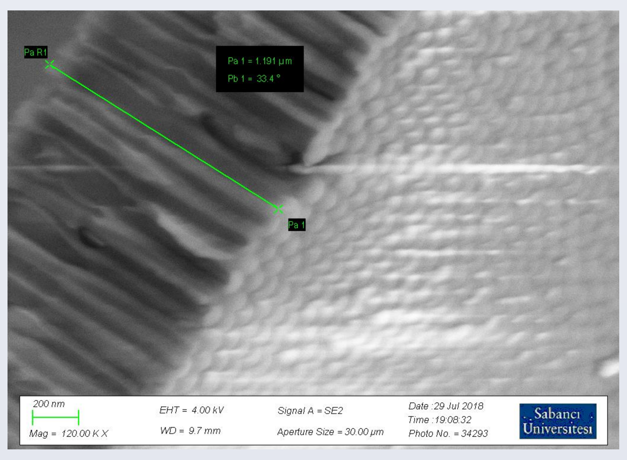
In our experiments, we fixed oxidant amount, which is 0.243g, for every single experiment. However, several different parameters are used for methyl orange and polypyrrole.

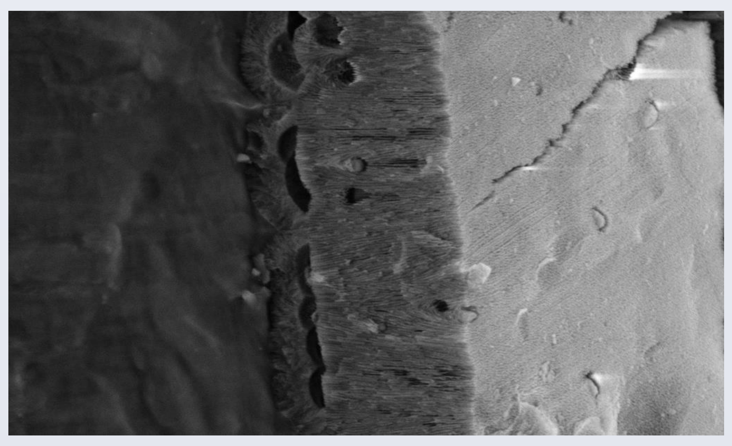
## AAO TEMPLATES

Anodic oxidation (anodization) is the process of forming an oxide layer on the metal surface by electrolytic treatment in suitable solutions. Oxidation is bound to the desired metal system as an anode. Al is oxidized very quickly under atmospheric conditions. This oxide layer formed is a protective and impermeable structure and provides alumina corrosion resistance. The thickness of the naturally occurring oxide layer varies from 35 nm. The oxide layer at this thickness has a limited corrosion resistance and can not protect the base material in aggressive environments. It is possible to improve the corrosion resistance by increasing the thickness of the oxide layer on aluminum by electrochemical processes. The thick anodic layer obtained by anodic oxidation has higher corrosion and abrasion resistance.









**Effective Parameters on Anodic Oxidation of Aluminum**

**Electrolyte type**

Comparisons of pore diameters of films obtained after anodization with different acids are as follows;

Chromic acid> phosphoric acid> oxalic acid> sulfuric acid

**Effect of acid concentration**

As acid concentration in solution increases, pore diameter also increases.

**The duration of the anodic oxidation process**

As extension of process time increases the thickness of the oxide layer also increases.

**Effect of current density**

. The higher the current density, the faster the oxidation occurs without dissolving, in this case it is possible to obtain a thick oxide layer with high porosity and high current densities

## CONCLUSION AND FUTURE WORK

Several polypyrrole nanotubes with different component parameters are produced. Effects of parameters are obtained. For example, increasing polypyrrole molarity in the solution results in increasing conductivity of formed nanotube. Increasing molarity of methyl orange prevents the formation of nanoparticles on the nanotubes. Not using methyl orange results in forming nanoparticles instead of nanotubes. Using ethyl alcohol or distilled water in drying part has no effect on formation of nanotubes or on nanotubes' conductivity.

Producing of anodic aluminum oxide with different electrolyte type, acid molarity in solution, voltage values, electro polishing solutions, anodizing time and polishing time are tried. From these, it is learned that increasing acid molarity, increasing voltage, results in increasing pore diameter. Increasing anodizing time also increases the length of the aluminum oxide tube. We also concluded that the best way to electro polish the aluminum to make ready for anodizing is using perchloric acid and ethanol solution at 8 volts, 1A for 10 minutes.

For further work, to increase the biocompatibility rate of the sensor, another structure directing dye can be used while producing nanotubes.

## REFERENCES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