Nanobio Technology Enabled Point-of-Care Devices
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Lecture - 20
Strategy for Electrochemical Detection and Tuning of Electrocatalytic Activities (Continued)

Ok students. Last time I taught you the strategies of the different pre-treatment method and enhancement activity deactivations by different different method. Let us continue this topic and I will complete this with some basic information's and some advance level for this, all the treatment applications for the sensor development.

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So, the tuning of the electrocatalytic activities that can be done by different way, so I taught you like different tuning method like one treatment tuning is the chemical, 2nd is

electrochemical then some mechanical right. Then 4 we taught you some other treatment method that I am going to tell you something else also today.

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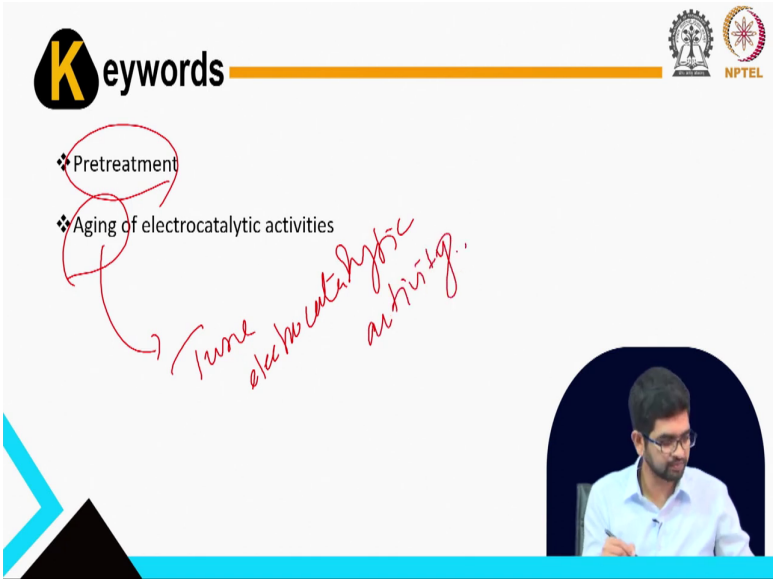

So, this is the main keywords that I taught that the pre-treatment and the aging effect and how to tune electrocatalytic activity.

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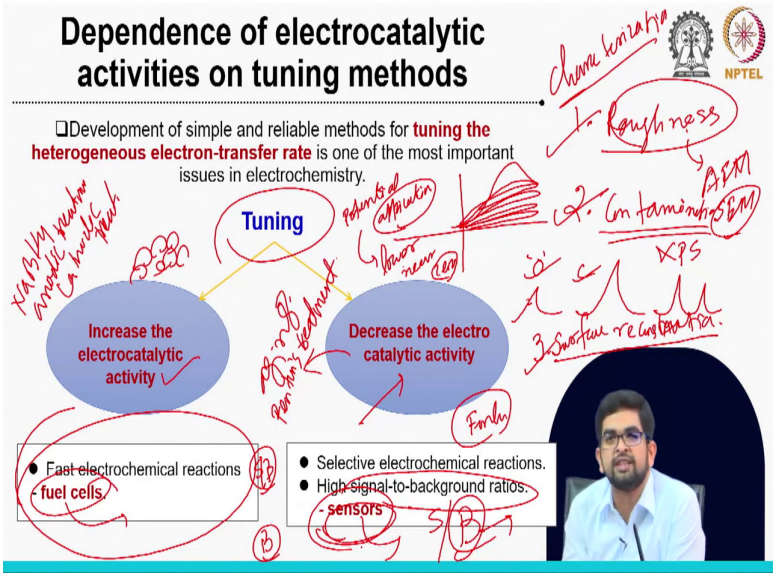

So, let us summarize. So, dependence of electrocatalytic activities on tuning method: So, whatever development whatever catalytic activity we are developing for this simple method we are using, they it has some impact on surface roughness, surface electrocatalytic activity, surface contaminations.

So, there is some different different factors you have to remember when you will investigate all the treatment method on the electrode surface right. So, first roughness, so, how we can how we can investigate this surface roughness, AFM study atomic force microgram that you have to check.

Also, you can check for the nanomaterial case SEM image you can take Scanning Electron Microscope image also you can take you can see the surface. So, this kind of characterization technique you have to follow and definitely after treatment before treatment you have to

check their electrocatalytic activity by measuring just by cyclic voltammogram. Simple electrochemical method cyclic voltammogram.

How we will check? So, just before treatment you may measure just like hydrogen peroxide oxidations or maybe you can measure like a hydroquinone or benzoquinone oxidation reduction space or glucose oxidations. So, before treatment you can measure something like this after maybe pre-treatment or you can check it then something like this then check after the tuning protocol, maybe the it can be here, maybe it can be here, it can be here. So, that story you can find out. So, one is the surface roughness for surface characterization.

Second you can measure the surface contamination. So, how you can measure the surface contaminations? You have to measure XPS study X-ray photoelectron spectroscopy that study you have to measure. You may get like in a gold case for example.

So, gold peak you can see right so, before and after treatment maybe if their gold peak is changing or not. On second you can check the carbon peak. So, if there is carbon contaminations or not. So, carbon peak before and after treatment that carbon peak you can check.

You can check the oxygen peak if there is a change of the oxygen peak or not. If there is a organic staff region on the surface and the after treatment then you can see the carbon and oxygen both maybe can change right. So, these things also you have to check. So, roughness, contaminations and anything else you want to check.

Just one factor I told you know last time the surface reconstruction. This is just a hypothesis I told you that can happen during the pre-treatment and aging case. Means after the pre-treatment maybe your surface is highly active, your atom of the surface is highly active or they can reconstitute each other before treatment and after treatment. After treatment they become where they feel some strain and after the treatment suppose you are going for Fenton treatment or suppose you are going for aging something effect.

Then this highly you can go again the reconstructions. So, you can come to the some lower state active stage that is why maybe you are getting lower activity. So, that is phenomena can be explained by surface reconstructions ok. So, surface roughness, contaminations and surface reconstruction like this way you can explain.

Now, so I can summarize the tuning effect there is two kind of tuning can be done. One is the increase the catalytic activity and decrease the electrocatalytic activity right. So, increase can be done. So, I told you like electrochemical treatment like sodium borohydride treatment, like anodic treatment, like cathodic treatment. So, these are the they can help increase.

And decrease electrocatalytic activity means you can go like a decrease like aging or you can go for Fentons, Fentons treatment right. So, like this way you can decrease the electro catalytic activity also. So, you know the first catalytic activity why we need something in the fuel cell basically we need highly catalytic active material. This case you can go for the increase the catalytic activity.

Decrease mean, especially the sensor case you need the moderate activity for those case you should know you should know that their signal to background ratio should be high right signal to background ratio. So, your background current should be minimum for that you have we may need to go for the decrease the electrocatalytic activity.

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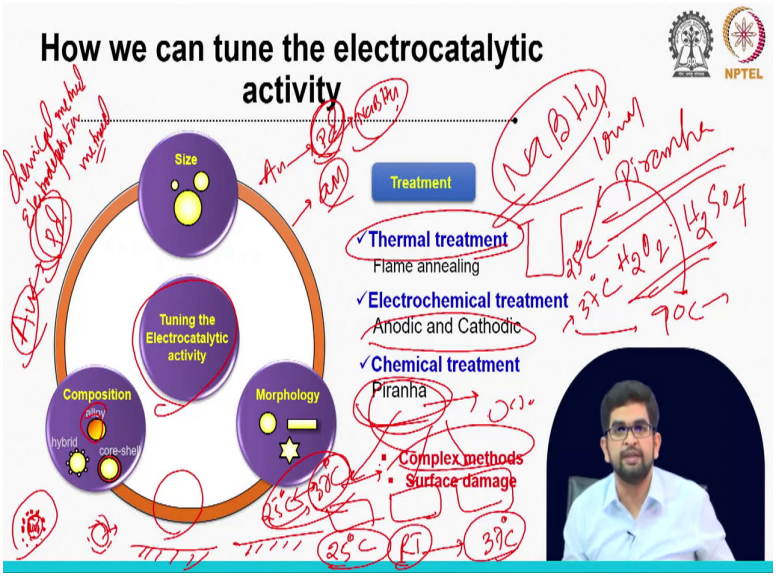

So, this all the tunes activity that I taught you the last class like size effect, morphology effect, compositions effect they are all the treatment right that is there can be the thermal treatment. Now, let us come here; thermal treatments in these cases like flame annealing, electrochemical treatment like anodic, cathodic treatment.

Sometime this kind of treatment is very simpler than the other treatment like flame annealing or any other complex treatment like piranha. This is also another treatment that is chemical treatment. You know the mixture what is the piranha? Piranha is a very very strong oxidizing agent.

It is the mixture of hydrogen peroxide and sulfuric acid and this mixture can generate very strong oxidizing species and you have to be very much careful when you handle these piranha solutions. Immediately it can burn your hands if you touch this piranha solution.

So, that is why handling this kind of chemical is not easy. Maybe you see if you have some gold chips and if you clean the surface with piranha then your surface organic material that is contaminant can be removed easily. They can be easily oxidized. The surface become very very active surface, but this handling the piranha is a very very dangerous, you have to be very much cautious about this highly oxidizing agent there.

So, that is not much favourable for handling this kind of chemical that is why we are not giving much importance for this treatment for the catalytic activity because they are very much complex. Also, sometime because of the highly oxidizing species they can damage the surface also. You have to very much optimize those treatment methods. So, today I am just going to tell you this this piranha treatment one.

It also can increase the electro catalytic activity, but you have to be careful. That is why we have to we have to search something new treatment that is very very simple treatment and that treatment is sodium borohydride treatment. Right Why? This is very simple let us make a 10 millimolar solutions and dip your electrode inside the solution and then you can get it if they are very mild.

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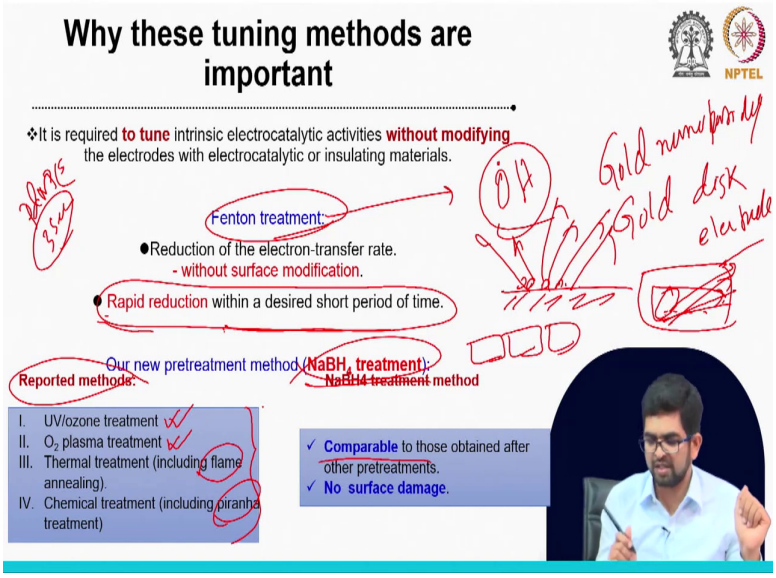

So, that is why this kind of tuning methods is very very important. So, now you can see, today again I will let you know some explanations like why this kind of tuning method is very important and why their activity is changing. See. So, for the tuning we are using Fenton treatments. I have already told you there reason why it can enhance the catalytic activity or deactivate the catalytic activity.

Mechanical pollution can enhance, but Fenton can deactivate the catalytic activity because hydroxyl radical it is generating right. So, this case of a treatment like Fenton if you go for the gold nanoparticle, gold nanoparticles you can see the surfaces, roughness is not that much changing. But if you see the gold disk electrode, just I am summarizing all the treatment factor that I taught right gold disk electrode you see the surface roughness change.

So, rapid reductions within a desired short period of time sometime we may need sometime we may need the rapidly we want to decrease the electro catalytic activity then which treatment we will use right. So, still you have some scope like let us find out something new treatment method.

So, I am going to tell you there is some other treatment methods also still available like UV ozone treatment or O 2 plasma treatment. If you go for this kind of treatment plasma treatment, they also can enhance the catalytic activity, but why it can enhance? Because this plasma also can remove this O 2 plasma, they also can remove what the organic contaminant from the surface all the contaminant can be removed by plasma O 2 plasma.

So, like you have to check your all the electrode chips inside the O 2 plasma chamber in the O 2 plasma chamber then you turn on the O 2 plasma then you will see the bluish color then this O 2 plasma will remove all the contaminant. But thing is that you need expensive instrument you need some trained persons and you need some pre-process this all the things can make the complex your treatment method.

Again, the thermal treatment you may need flame annealing, some cautious method you have to use. Piranha treatment is very much cautious and you have to you have to take the pre precaution right. There is this kind of drawbacks you have to just you have to check properly before going for the other treatment that is why I am always saying you should go for the simple treatment like the sodium borohydride I taught you.

So, this treatment is very much easier and, but this treatment again here comparable for other treatment know. Just remember I taught you for the palladium nanoparticles. Palladium nanoparticle case just after the sodium borohydride is how much like 3 second, then remember then it can improve the catalytic activity. So, that is why and the surface also not much change surface roughness was not much change it not damage the surface. So, that is why this is very very simple treatment method.

So, that is why this kind of treatment method also you can try for your electrode surface electrocatalytic activity changes. So, another things I will tell you for like if you go back here like all the morphology change that I told you that also you have to keep in mind. Let us come this process.

You know the synthesis of the nanomaterial like how we can synthesize the nanoparticle, generally we are using two method right chemical method and another is the electrodepositions method electrodeposition method. I will propose sometime you may think about some new nanoparticle generations not only a simple the gold nanoparticle, not only the simple platinum nanoparticle or platinum nanoparticle let us go for something else.

It also can readily improve the activity, why say I told you know like gold nanoparticle and palladium nanoparticle this two nanoparticle we checked with the sodium borohydride activity and we find out palladium is the best. Why not something else like something alloy type why not, you please we may have we may think or may check like the who are means today I am just going to give you some new area some prospective. So, that you can think whatever I taught until now let us apply this on some application.

We are thinking for start your maybe PhD or maybe higher education's let us think like see like gold nanoparticle here inside the like your core and like in the outside you may design or decorate with some other nanoparticles suppose platinum. Let us check this activity with some other treatment like sodium borohydride treatment even you can see the degree of the enhancement, degree of the deactivations and suppose a gold, platinum with a highly expensive material.

So, you can go for the inside may be some one material outside you can use some expensive material right or you can go for the alloy type, definitely you can see some change of the electro catalytic activity. So, this kind of scope I want to give you let us you can try to think some new area of the change of the electrocatalytic activity and then use for some sensing applications then slowly I will teach you the next class these things for the biosensing application again.

You can remember like when we convert like gold to palladium then you can see the with the sodium borohydride treatment this activity was so fast and so high then you can achieve the attomolar detection. Why it is possible? Because this nanoparticle be is something else. So, that is why not why you should not try something else then why you should not try something else tuning factor for the biosensor development that is I am going to tell you now.

See, I am just going back that is why one by one today just I am summarizing like you may need to decrease the electro catalytic activity right. I told you the deactivations can be done by Fenton's, but it also kind of the mixture of the different chemical why not something other chemical you can try.

Like only reported Fenton's already like some group already tried on the gold disk electrode some group already tried on the gold nanoparticle let us try even something other particle other nanoparticle also something other bulk materials also you know we can check their activity changes.

So, this kind of lots of scope we have like high catalytic activity generally we may need we need the fuel cell. So, you can try like this kind of enhancement that I taught that can be useful like in the fuel cell, maybe like you can use like different alloy material and you can study those material not only for fuel cell now let us come to the sensing applications.

Now, you can see without deactivations also we can like I told you that for the sensing application we need lower catalytic activity, why? Because you need lower background current otherwise signal to background ratio, we may not we may not assume like reasonable value we may not assume.

But still we can think about without deactivation you can change the certain parameter; you can remember that I taught you like potential application right potential applications. So, although you may have the your catalytic activity of the electrodes very high, but you can apply the potential in the lower range or near lower range or near 0 right.

If you apply the near 0 then you can avoid some side effect like oxygen side effect or some interference spacing that present in your space in your systems like ascorbic acid, ureic acid those things also you can avoid those factor. So, sensing applications tuning can be done without very rigorous treatments also that you can think. So, you have lots of scope that is why ok.

So, those you should remember ok and thermal treatment cases sometime we are using like different, you have to check like your electrode, if you change the temperature like 25 degree Celsius to 37 degree Celsius maybe your sensor activity can be changed, go to the 90 degree Celsius even more than this your sensor activity can be changed.

But how long you can store that you have to keep in mind, that is why sometime this thermal treatment we are not giving much importance because when you increase then come back to the again the room temperature. Mainly for the sensor development for a biosensor development you have to come back to the room temperature and then you have to fabricate your all the material.

But during this aging time there may be aging factor right. So, that you have to keep in mind during this aging time it can impact on the electro catalytic activity that you have to remember. Another thing when we are developing the sensor generally, we prefer the room temperature generally we are measuring the all the catalytic activity at 25 degree Celsius at the room temperature.

But sometime your catalytic activity may be specially biological activity is very good at 37 degree Celsius. So, you have to increase. So, at the 37 degree Celsius maybe how this temperature can effect on the material surface that also you can do some control experiment. So, what is control experiment?

Control experiment means suppose you have the electrode surface at the room temperature 25 degree Celsius you can check like on cyclic voltammogram of your sensor surface using some basic material, basic substrate that are using without biosensor modification then again

increase the temperature 37 degree Celsius using your basic substrate and check the cyclic voltammogram.

So, at the 25 and 37 what is the difference of the cyclic voltammogram, current, peak potential those things you can measure, even you can increase the different different temperature values more than 37 not too much basically biosensor case we are not preparing very high temperature. So, you can check some control experiment and check the temperature effect and then apply for the these things actual sensor applications.

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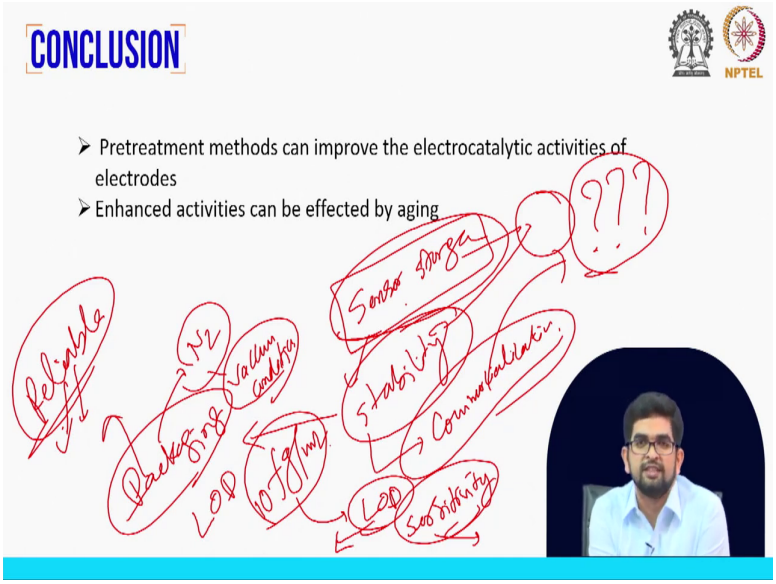

Those things you should keep in mind. So, like this way I am just summarizing you today all the treatment effect how you can use. So, basic things that is I just wanted to tell you that all the pre-treatment method these things as very important for electro catalytic activity, but you

have to think finally, how you can use those for the final applications and your sensor storage, sensor storage is very important factor that is called stability.

And that is very very important for commercialization why? Maybe you fabricated one sensor and you have to go for packaging this is the another important means which systems you are storing the electrodes, you may need to store in the nitrogen environment right or in the vacuum condition.

And you have to check during these storage conditions if this sensing activity maybe you got LOD some 10 femtogram per ml, but after the long-time storage maybe one months, two months like this even you have to check longer. Are you getting the similar limit of detections or similar sensitivity or not? This is very very important factor.

If you not getting similar limit sensitivity then your sensor is not reliable, reliability is very important parameter for the development of the sensor. If your sensor is reliable you can store for the long time with your proper packaging system then only you can think about the commercializations of your device. So, the things I am summarizing today that all the things is very very important for a if you really want to start your own like want to like your own startup your own company then the people should rely on your device on your technology.

So, sensor storing sensor stability this is very very questions mark nowadays, you can see lots of studies nowadays going on. If you check like cancer detection biosensor lots of study you will get, but why all they are not in the market you can see very certain chips are readily available in the market.

You see the glucometer only the device you can see easily available in the market, but some devices glucometer like devices are available very very expensive, but sometimes they are not also reliable they cannot give you the proper data. So, you cannot go for the longer I mean business with this kind of the product who are really thinking out their own business own startup they have to very much give the important distance a storage.

So, that is why I told you there is lots of conditions that can impact on your sensor stability like aging factor contaminations factor so why I taught all these conditions to give you this clear picture of the storage of your sensor. So, many things can hamper your sensor stability ok that you have to definitely keep in mind ok. So, that is all today.

Thank you very much then I will come again this kind of new technology things for enhancement, tuning and then applying about the sensor in the next class.

Thank you.