Experimental Physics - III
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Lecture - 25
Dielectric Constant of Non-Conducting Liquid

I will demonstrate another experiment on Dielectric Material. Earlier I have demonstrated how to measure dielectric constant of a solid, now this is another very simple set up for measuring the dielectric constant of a non-conducting liquid,

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Measurement of dielectric constant of non-conducting liquid.

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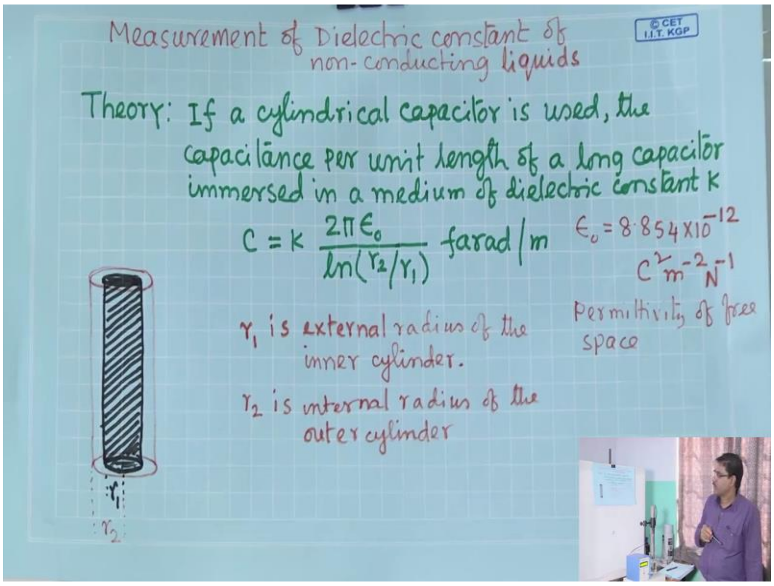

theory of this experiment is if a cylindrical capacitor is used the capacitance for unit length of a long capacitor emerged in a medium of dielectric constant K, so then capacitance C equal to K 2 pi epsilon 0 divided by ln log r 2 by r 1 farad per meter, one can easily derive this for cylindrical capacitor, one can derive this expression.

Here r 1 and r 2 are the internal, this is the external radius of internal cylinder, and this r 2 is the internal radius of the external or outer cylinder. coaxial to cylinder, coaxial to cylinder, ok; this is the inner cylinder; this diameter or radius of this inner cylinder it is the outer radius and if it has some thickness, so that is why we are taking outer. we are taking space between these two cylinder this one.

That is why it is an inner radius of outer cylinder red one and outer external outer; this is the internal radius of the outer cylinder and external radius of the inner cylinder. that is why this. If any thickness is there, so that will not come into the into this r 1 and r 2, so this spacing between this two surface of the cylinder is r 2 minus r 1,

This r 1 and r 2, one has to know or one has to measure and then from this formula you can see epsilon 0 is known to was, it is a permittivity of free space and this C is the capacitance, so if you can measure this capacitance then one can find out this dielectric constant of the material. However, there are seen practical case, in practical our actual practice there are error due to the stray capacitance or straw capacitance.

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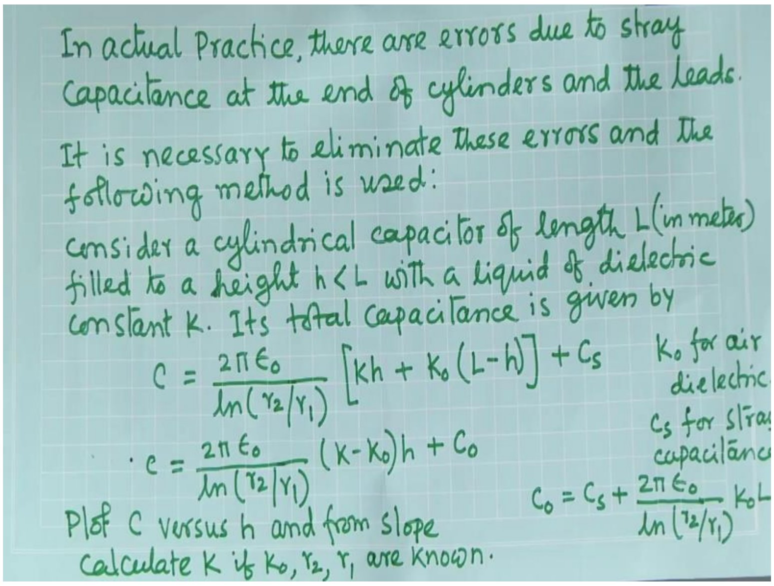

Due to the stray capacitance at the end of the cylinders and the leads, leads means, that is a power supply you use electrode, to give voltage between the two-capacitor plates. It is either parallel plate or a cylinder plate we have to apply voltage, means we have to apply electric field.

Electric field is equal to voltage divided by that distance between these two electrodes. There are some practical error, that is due to the is the end of the cylinder and the leads electrodes, it is necessary to eliminate these errors and for that this method is followed.

Consider a cylinder cylindrical capacitor of length L filled in a height h less than L. we will filled with a liquid the cylinder with a height h which is less than length of the capacitor, The dielectric constant of course K as I mentioned, then its total capacitance is given by this Kh plus K 0 L minus h. total capacitor length is L, so out of L, so h this height is filled up with liquid and L minus h this half is filled with the air, or this is the free space.

capacity capacitance will be capacitance for this part plus this part, so that is why, that is why this is the common so this, plus this straws capacitance, Some as I mentioned this will come from the end of this cylinders and leads. If this connection terms this C s, we can write this one 2-pi epsilon 0 ln r 2 by r 1 K minus K 0 h plus C 0, where C 0 is this. In C 0 you see C s this correction term plus this constant term because this all parameter are constant for a cylindrical capacitor, so r 1, r 2, epsilon 0, K 0 and L, so these are constant. This also C s also constant because this whatever the error will come from the end of the cylinder and leads so that was constant, C 0 will be constant.

here the procedure we will follow that we will vary h, will vary h means we will filled up with liquid in different height and for each height we will measure the capacitance, we will measure the capacitance. Then we will plot capacitance versus the h and from this plot, you will find out the slope and that slope will be this, slope will be this, Slope will be this.

from that slope if you know K 0 value r 2 and r 1 then you can calculate K, thus we can find out the dielectric constant of that liquid where this way we are eliminating this error due to this that C s, ok; which is coming from the cylindrical ends and the leads. this is the procedure for measuring the dielectric constant of a liquid. This is the experimental set up. what is there?

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This is the insight I cannot show you. Inside we have coaxial cylindral, ok, coaxial cylinder inside. Now, that and this, this is the just outside it is not cylinder. This cylinder we are not using because no power we are not giving there. Inside it is there, and that cylinder inside that cylinder, we can move. We can move with this and there are scale here I will show you, there are scale here later on I will show you. This is the liquid benzene liquid, this is the benzene liquid. Now, here scale I hide here 0 is 0, 1, 2, 3, 4, 5. This centimeter it is there.

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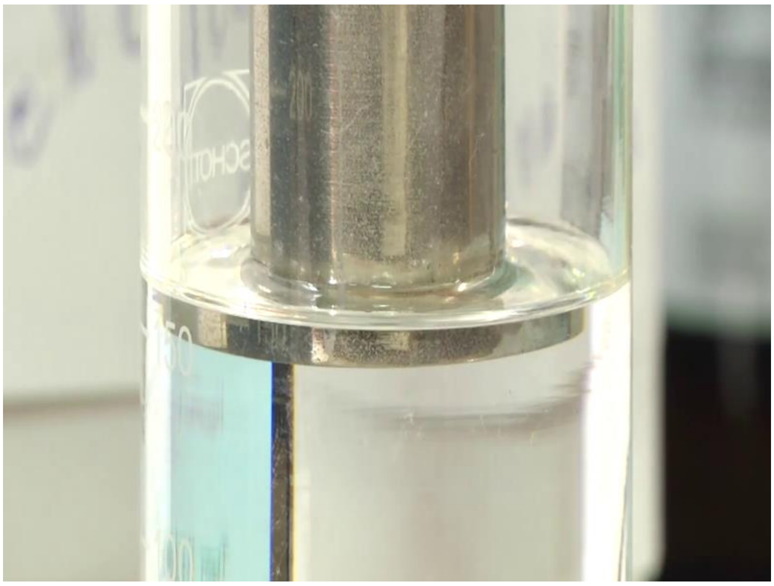

Now, I will put this up to 0 means there is no liquid inside the, so is up to 0 marks, Here it is written it you cannot see it, but I will show you. It is a up to 0 marks or so for that whatever this we will make it that a 0 adjustment. We will make it 0, this is the capacitance meter it will directly measure the capacitance, but oh it is an it is on or off. It is on, let it be on.

Let me show you, this is the scale here. There is a scale, there is a scale I can put torch you see. It is a 12, 11, 10, then 9, then 8, so up to 0 marks; I have put up to 0 marks here, for this I will liquid height is 0, h, whole length is filled up with is air. This I will make 0. we have to adjust to 0. I think yes. Just I will. liquid air now at 0 position, so h is 0, h is 0. We will note down that h and for corresponding this one will make it, make it 0, ok.

Now, I will liquid just I am inserting these coaxial capacitor cylinder into the liquid by 1 centimeter say it is a here one has to see it is by 1 centimeter. I will put by 1 centimeter, and then what is the reading? I will note down 3.24 pico-farad. Then I will insert by 2 centimeter. Then what is the reading? I have to note down 7.47, this way I will continue for 3, for 3 what is the value, for 4 what is the value, for 5. up to as long as we will take let me how much we can go. I think yes. I can go up to 5, we will get this for 5 centimeter 21.68.

Now, again we will decrease the height. Now, at 4 what is the value, now 3, 2, so this way we will continue the set of data. we will take average of that one. This way what we are getting? I am getting the, I am getting the height liquid height or liquid length of this in the in the capacitor and rest of the L minus h will be the vacuum part, ok; air part of the empty space.

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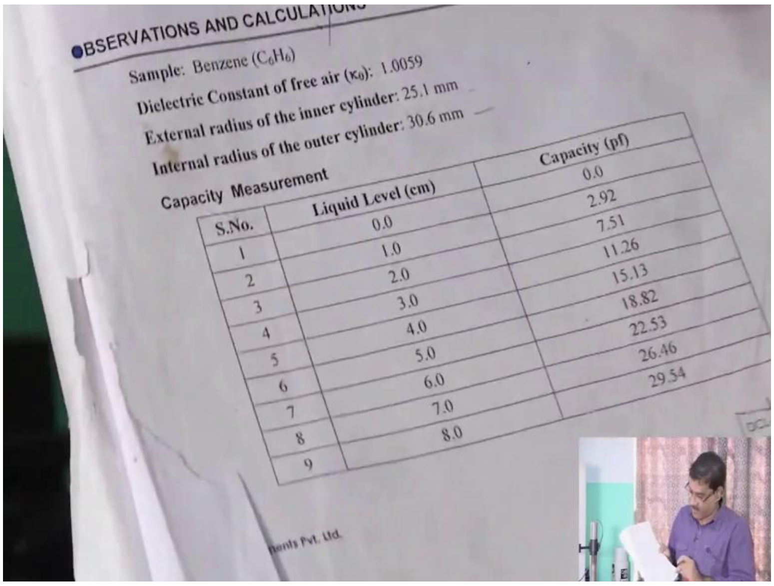

OBSERVATIONS AND CALCULATIONS

Sample: Benzene (C_6H_6)

Dielectric Constant of free air (κ_0): 1.0059

External radius of the inner cylinder: 25.1 mm

Internal radius of the outer cylinder: 30.6 mm

Capacity Measurement

S.No.	Liquid Level (cm)	Capacity (pf)
1	0.0	0.0
2	1.0	2.92
3	2.0	7.51
4	3.0	11.26
5	4.0	15.13
6	5.0	18.82
7	6.0	22.53
8	7.0	26.46
9	8.0	29.54

Now, we will get this you see that dielectric constant of free air 1.0059. External radii of the inner cylinder 25.1 millimeter; internal radii of the outer cylinder 30.6 millimeters; this is the is the parameter is given, so using that parameter now at different liquid level we are we have noted down the capacitor.

then we will we have to plot, I this C versus the liquid height, then it should be straight line. In piece of it should be straight line and from that slope, from that slope we will find out the from the slope we will find out the constant K value. We will find out the that dielectric constant K value, knowing other value we are putting and C is measured at for different h. from graph we will get slope, from slope we will get the K value, ok.

This is very simple experiment, but every nice to calculate find out the dielectric constant of non-conducting liquid, ok.

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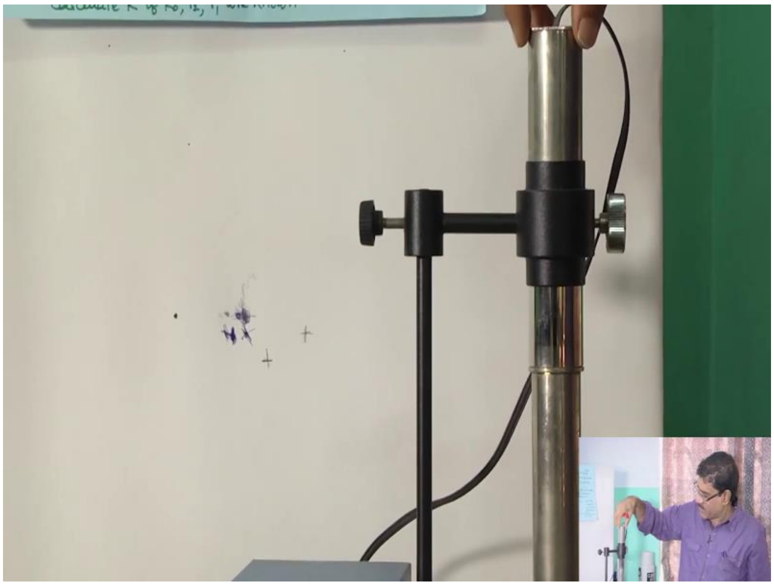

I think; so this one is power supply as well as the this the capacitance, We are measuring it is connected with this capacitance meter, nothing needs to show you here because inside that capacitor I cannot show you because this the compact system only we have very nice, this very simple and we have very nice option to change the height of the liquid or level of the liquid and directly we can get the reading from simple capacitance meter. I think I will stop here.

Thank you.