What is obvious reasons? Cost, but you still want to do it. What is the second reason why you want to do it for, composition.

So sometimes you want chemical composition, and you are getting a lot of material. So you are, again, you are looking at composition that composition will give you a lot of clues to where it is coming from just getting mass distribution is not enough, multiple sources may be giving it you will get size distribution, it may not be just enough. So people are always trying to find out the cheapest method of doing it.

What we call a source apportionment, we have source of apportionment and you can do source apportionment as long as you get a very specific signal for a source. But sometimes it is mixed signals, you don't know how to resolve signals. One way of resolving these signals is by using chemical composition. If you have enough information in size distribution that may be enough for you to make source apportionment. That is fine, that is good but if you want complete information, you need to get composition which means you need actual physical mass. That is one reason the second disclaimer here is this optical method is not measuring aerodynamic diameter, this is measuring a scattering diameter. So, it is a different diameter than what we define as PM 10 it may be the same for some particles, but it is likely that it is not.

So, you have to be very careful when you are reporting this as PM 10 versus something else you have to make sure that there is a correlation between this and that so, the only way to do a correlation is you do PM 10 using the APS. APS will report the aerodynamic diameter. You can put this versus this you can see this is this instrument is much cheaper when this instrument obviously you can see the amount of electronics and amount of testing involved in it.

So, this is always going to be the challenge and currently we are a lot of groups working on trying to get cheap instrumentation. Because, one of our goals in fate and transport, as we will see in the next is to have a wide distribution of measurement. We want atmospheric measurements, somebody will give you some number and does not we did not know what it means, as you saw in the quiz paper. We don't know what it means I say composition is this much what does it mean? I have no idea.

Is it a composition that is arising out of one specific event that happened this afternoon? Or is it a continuous thing? Or it is periodic? We don't know so, all of these are gives information of what is happening in the system. And the system is huge it can be system can be city of Chennai, it could be system can be city of Chennai and the surrounding 50 kilometers. It can be the entire state of Tamil Nadu and the Bay of Bengal it can be the entire southern subcontinent.

And the timescales are varying and all that size. As it is the case with Delhi we don't know what is the system boundary there because of these kind of things. So the full information of PM will give a lot of clues to where what the problem could be.

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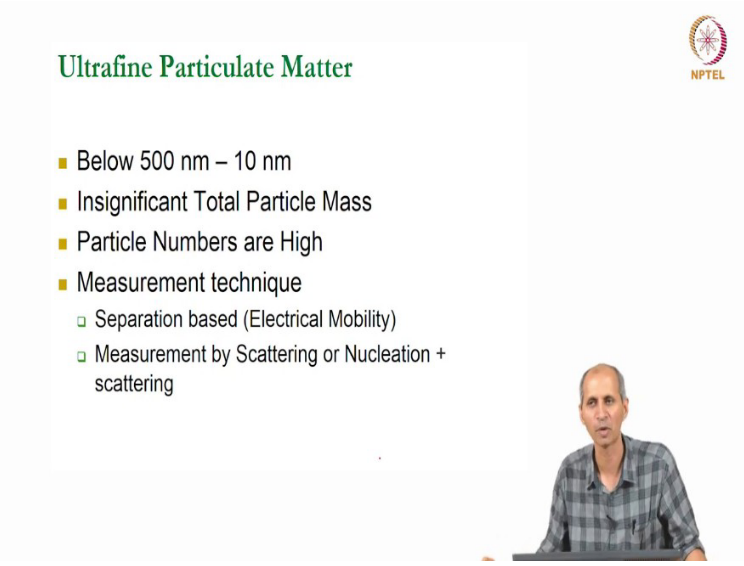

So, there are further something called ultra-fine particulate matter these are particulate matter which are below it typically is 300 nanometers and below 500 nanometers in that size range. The reason this is important is a lot of emission coming from vehicles, diesel analyzing particulate matter are in this size range, it is known very well known that then it is if you look at the particle size distribution we have seen that there is something called as a condensation and nucleation range which starts from the lower end and the higher end of particles are mainly from mechanical breaking, breakage, erosion that can also because they are originating from larger particles this is originating from vapor. So, originating from vapor is combustion are all like that there is a vapor phase at very high temperature and it condenses forms of particles thermodynamically from the smallest size possible.

So that will be a sphere very small nanoparticle and condensation occurs and the particle grows in size depending on how much exposure is there in the system. So these are all small particles nanoparticles and there is a general theory. So if you look at the trend of PM that is has a health effect. Earlier they had no idea they are all PM is not that then they said PM 10 because PM 10 goes into the nose then is at PM 10 does not go into the lungs it stays somewhere near the nose and throat PM 2.5 goes into nose.

Now the theory is further down we are going further down you are already in the nanometer nanoparticle range is few 100 nanoparticles, very difficult to measure. So how do you measure nanoparticle nanoparticles you cannot do gravimetry. You have to collect millions and millions of particles and still you are not sure whether you are collecting that size range. Classification is very difficult because classification by aerodynamic method is difficult. Because that is based on momentum and the mass of particle is now gone so much that you cannot use momentum for classification anymore. So, people use what is called us electrical mobility.

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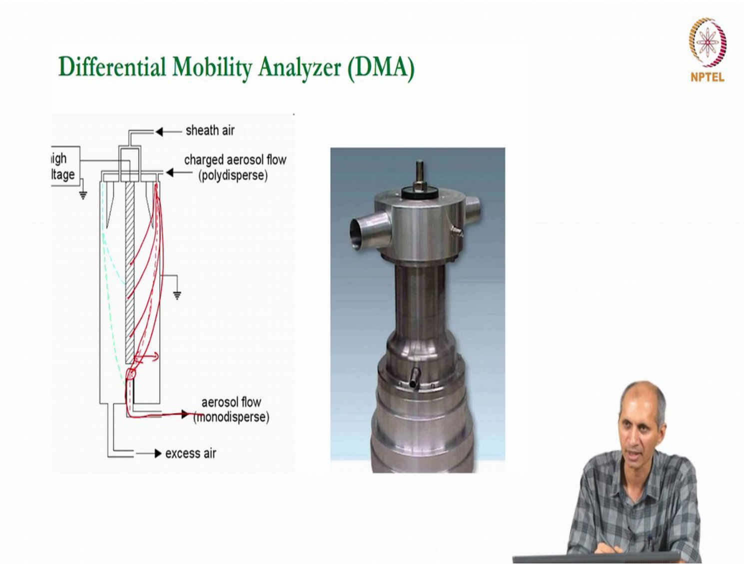

So electrical mobility, and the instrument that is used to make is called as a differential mobility analyzer. And this instrument, what it does is it charges all the particles coming in. But depending on the size of the particles, different charges accumulate on particles, and then there is a flow and there is a potential difference that is placed across these 2, there is this is a concentric cylinder in the center there is a like a cylinder small cylinder and outer there is a bigger cylinder.

Between this there is a potential difference. This potential difference will pull particles of a certain charge towards it and plus it is also moving so based on the electrical charge, and the flow particle also has an aerodynamic behavior there is a resultant trajectory as seen by this red and green dots in this picture here. So, for a particular size of particle at a particular voltage, you can expect one particular directory, if you change of this directory will change.

So, what is in this instrument has an opening here, particles of that trajectory which correspond to that will go into this opening and be taken out of the stream rest of it will go out. So, it is like doing mass spectrometry, you are only giving that one particular size tag and you are, you are allowing one of them to go through the rest of them, you are taking out. So, you are separating it like that.

So you are changing the voltage from one value to another value. So different particles have different trajectories at different times, and it can throw the entire thing. You only want one particle size you can fix the voltage and only that particle size. We will go through but if you want the full scan like the mass spectrometer you have changed the voltage and the under trajectory will keep changing.

Whatever this particle will be here next here is the voltage will be your next here and next then it will go here then it will go through so on all particles go through this depending on what is your design, but we still don’t have a method of measuring it.

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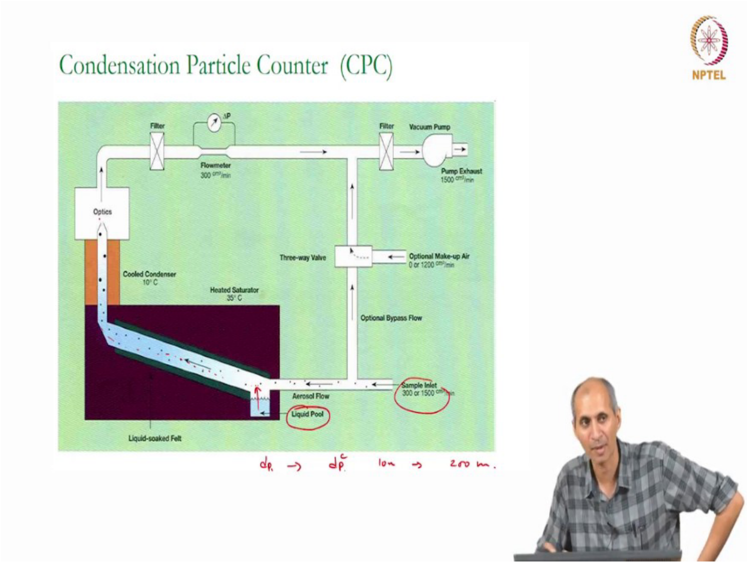

So, that method of measurement called as a condensation particle counter (CPC). These small nanoparticles you don't have a way of counting it yet. So, but you will know how to count particles that are in the range of sub about 0.3 microns 0.4 microns. So, this is using the scattering instrument, which we already saw that the limited there is about 0.3, 0.2 microns. So, you allow the nanoparticle to grow to that size.

How do you allow it to grow? This is a particle is coming from here, the sample inlet particles are coming in here, and it is exposed to a saturated environment of some vapor? So, there is a liquid, here and this is evaporating and it is condensing on the particle you can see this particle has a residence time in this region and it grows to a certain size. So, particle of dp 1 grows to a particle of dp 1c let us say so, a particle of 10 nanometers will grow to say about 200 nanometers, a particle of 20 nanometers may grow to 300 nanometers and so on.

So, there is a correlation between what is coming in and what is going out because the rest of it is fixed so based on that you can calculate the particle size distribution and back calculate, what is the particle size that is coming through.

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So, very complicated instrument, the entire thing is called as a scanning mobility particle sizer or SMPS very expensive instrument cost around 50 lakhs, 60 lakhs as you can imagine, but it is used a lot in trying to understand what is the distribution of particles all the way from 10 nanometers up to 10 microns, you can do the entire thing in 1 sweep.

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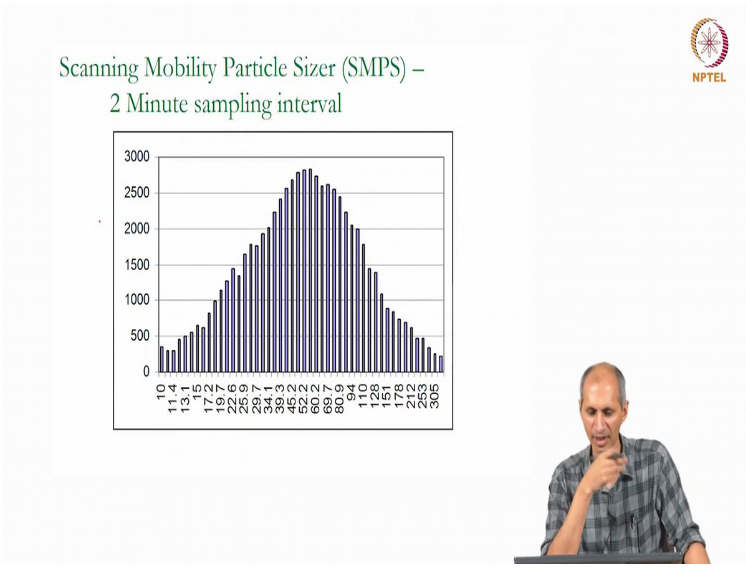

You will get data that looks like this you will get all kinds of things, so we will continue the rest of it tomorrow looking at chemical analysis and physical analysis.