

hello my name is shankara raman from the department of chemistry at iit madras this is the second lecture in the organic chemistry fundamental concepts lectures in this particular lecture we will consider two aspects one is nomenclature of organic compounds simple organic compounds how to name them and secondly you talk about the concept of isomerism in organic compounds now carbon atom has the ability to combine itself to form long chains of carbons for example you have methane ethane propane butane you can go all the way up to longer chains of ten or twelve carbon chains essentially each one of this representing a carbon

So this would be two four six eight ten twelve

So this will be down again c twelve chain is what we are representing

So because of this property which is known as catenation the ability of carbon to bond with itself forming long chains millions of organic compounds can be formed just as hydrocarbon one can imagine

So many

So if you incorporate heteroatoms like nitrogen sulfur phosphorous silicon and

So on in the carbon framework you can imagine innumerable number of compounds can be synthesized

So there is a need for systematically naming the organic compounds and the international union of pure and applied chemistry which is known as iupac international union of pure and applied chemistry its an organization international organization it has come up with certain rules and regulations to name systematically organic compounds however complex the structure may be there are ways of naming the organic compounds systematically

So that once we know the systematic name we can reproduce the structure of the organic compound safely without any mistakes

So let us start with simple alkanes this is called methane

So the corresponding radical would be called the CH_3 which will be methyl radical this is ethane the corresponding radical C_2H_5 or C_2H_5 would be called ethyl radical ethyl radical this is propyl this is propane this is butane and

So on

So corresponding to the homolog series of c one c two c three c four in the next homolog series will be pentane hexane heptane octane nonane decane undecane dodecane tridecane and

So on

So the corresponding $\text{C}_{20}\text{H}_{42}$ this corresponds to $\text{C}_n\text{H}_{2n+2}$ rule which is the saturation saturated hydrocarbon molecular formula for example

So this would correspond to eicosane $\text{C}_{30}\text{H}_{62}$ would be corresponding to the name triacontane

So the hydrocarbons always end up with the a and e as the terminal name of the compound is ending up with a and e in penta means five buta means four propa means three ether means two metha means one and

So on that is how the hydrocarbons are named in the iupac system of nomenclature now if you consider branched systems like this for example now let us talk about a simple branched system which is only one branching in this particular position here in a branched system like this the longest carbon chain is taken and the number is given from the longest carbon chain closest to the branching

So this is the parent hydrocarbon is pentane and in the two position there is a substituent which is the methyl group

So this is two methyl pentane one can do a mistake of naming it slightly differently which would be the wrong name for this particular compound instead of starting the number from the right hand side to the left hand side one can start from from the left hand side to the right hand side and call it as four methyl pentane this would be a wrong nomenclature because substituents where the branching is taking place is always given the least number that is possible

So this is two methylpentane and not four methyl pentane

So that is rule number one branched alkane longest chain is taken and then numbering starts closest to the branch let us illustrate this with one more example also you consider for example a heptane

So the longest chain if you consider here would be one two three four five six seven

So it is a heptane and start the numbering from the position closest to the branching this is the position that is closest to the branch

So this will be the numbering sequence of numbering now there are two methyl groups one

in the two position and one in the four position

So it is 2,4-dimethyl butane you cannot number from here because that end is farthest from the substituents which are the branching in this particular case

So this is 2,4-dimethyl pentane the heptane the die essentially indicates there are two methyl groups if there are three methyl groups for example let us put one more methyl group here this would correspond to this particular molecule would correspond to 2,3,4-trimethyl butane

So di tri tetra penta hexa and

So on indicates the same substituent occurring in more than one time if it occurs twice it will be di it occurs thrice four times five times and

So on as many number of times as possible if it occurs that is the prefix that is given to the nomenclature in this particular case

So if you were to name this particular compound let us consider this simple molecule the systematic nomenclature would be the longest chain is a four carbon chain one two three four So this is a butane and if you consider on the butane carbon number two and carbon number three there are dimethyl substituents

So 2,2,3,3-tetramethyl butane would be the name of this particular compound in the two and two position in the same carbon namely carbon number two there are two methyl groups

So 2,2 and 3,3-dimethyl 2,3-dimethyl

So totally four methyls are there that is why it is tetramethyl compound

So tetramethylbutane is the name of this compound and the 2,2,3,3 indicates the position of the methyl groups in that particular structure in terms of the nomenclature that is being given

So if two or more identical groups are present then you give the prefix di tri and

So on depending upon how many number of substituent identical substituents are present in the system now suppose if two side chains of equal length are there then you have to select the one with the more branching that is illustrated by this particular example let us for example take this molecule if we consider this molecule this would be one two three four five six seven eight nine ten this will be ten if you start with numbering from here this also would be ten one two three four five six seven eight nine ten

So now you have a problem of whether to start the carbon chain numbering from here or carbon chain numbering from here now the one these are equal length from carbon one to carbon 10 here carbon 1 to carbon 10 here they are equal length however if you consider the branching this has more branching this has two methyl groups in the branching this has only one ethyl group in the branching

So start with the carbon which has the more number of branching in the chain and number accordingly

So this would be corresponding to 3,3-dimethyl decane this is a C₁₀

So it is dodecane sorry this is a decane dodecane will be C₁₂ but in the phi position if you look at there is a butyl group which is one two three four there is a butyl group which corresponds to this in the butyl group in the two position starting number one two three four this is a butyl group the two position there is an ethyl group

So this would be 5-ethyl-3,3-dimethyl decane if you start numbering from here to here that will give more numbers in terms of the substituents that are present here the sum of the numbers should be minimum

So this is a systematic way of giving a nomenclature for this particular compound let us take another molecule let us take this particular molecule this as 1,2,4,6,8,10 again decane is a decane system if you look at the numbering in the four position there is an ethyl group in the ethyl group in the one position there is a methyl substituent present here

So 4-ethyl-1-methyl decane that corresponds to the branching here one methyl ethyl is the branching that goes here in the five position you have again one methyl propyl

So this is a hyphen here 5-ethyl-1-methyl propyl

So in the five position there is a one methyl this is the methyl group and this is the propyl chain as it is attached to the methyl group for example

So 4-ethyl-1-methyl ethyl 5-ethyl-1-methyl propyl decane sorry decane is the name of the compound it is a cetane chain there are two branching chains that are there each of the branching chain is first given the primary number to which the main chain is attached to it is attached to the four position and it is also attached to the five position the two branching chains now what is the branch is described within parenthesis in the four

position there is a one methyl ethyl group here is actually an isopropyl group but isopropyl is not an IUPAC nomenclature

So it is mentioned as one methyl ethyl group then in the five position you have a one methyl propyl group this is actually an isobutyl group but you do not mention it as an isopropyl group in the or it is a tert-butyl group is what is represented here but that is represented as a one methyl propyl chain is what the longest chain is here

So one methyl propyl the name is the systematic name for this particular compound now this is as far as the saturated hydrocarbon with the branching and

So on is concerned the nomenclature goes like this now whenever you have functional groups functional groups are the ones which contains the either a carbon carbon double bond or a triple bond or a functional group like oxygen nitrogen phosphorus sulfur and So on are present in the organic molecule the order of preference of functional group with the increasing order of preference if it is written then it is carboxylic acid which has a higher preference compared to sulfonic acid which has a higher preference compared to an ester functional group which has higher preference than an acid chloride you can simply mention it as an acid halide X is a halogen it could be chlorine bromine or iodine then comes the amide functional group then comes the cyano functional group which has a higher preference over an aldehyde functional group which has higher preference than a ketonic functional group and higher preference than a hydroxy amine functional group then a C double bond C and a C triple bond C kind of a functional group

So this is according to the IUPAC nomenclature if you have a carboxylic acid functional group in the molecule and hydroxy functional group in the molecule the carboxylic acid functional group gets a higher preference the molecule is named as a carboxylic acid and not as an alcohol I will simply explain this with an example we take a simple example like this this compound can be either named as an alcohol or it can be named as a carboxylic acid according to the IUPAC rule this gets the higher preference in terms of the preferential treatment of the higher order of the functional group compared to the hydroxy

So this is simply named as one two three four it is a butanoic acid with the space between butanoic and acid all the carboxylic acids are named as oic acid it can be methanoic acid which is a formic acid for example this would be propanoic acid So you write propane oic is the suffix that is added and separately acid is written that is how the carboxylic acids are named

So this has a substituent in the three position

So this would be three hydroxy butanoic acid you do not have to say one butanoic acid because carboxylic acid cannot be in the middle of the chain it has to be always in the one position only because it has the highest priority

So you do not have to name the number corresponding to this position

So three hydroxybutanoic acid would be the correct nomenclature for this particular one not it is not for example four carboxy butane to all this would be a wrong number this is not giving preference to the carboxylic acid functional group it is giving preference to the alcohol functional group which would be wrong according to the first rule of the IUPAC in terms of the functional group some of the functional group gets higher priority than the others

So that has to be taken care of carefully in naming the organic compound functional groups such as phenyl which is C_6H_5 which is this particular group this is the benzene without a hydrogen C six H five would be the phenyl group halogens alkoxy they always come as prefix substituent

So what is meant by prefix substituent let us take the example of let us say X is equal to bromine now you can call this as butyl bromide or bromobutane the systematic nomenclature tells you that this has to be two bromo butane

So this is the correct nomenclature for this particular compound similarly if you consider this particular compound here this would correspond to methoxy which methoxy one methoxy propane

So this would be the systematic nomenclature for this one

So these functional groups are always added as prefix functional group and not as the suffix functional group in the systematic nomenclature of we have a carboxylic acid the suffixes oic acid if it is a sulfonic acid then you call it a sulfonic acid itself if it is an ester functional group you call it as weight as the suffix in the compound let us for example take the simple example of let us call this as CH_2CH_3

So this would be essentially ethyl this is alcohol part is first written and then it is C

it is actually ethyl acetate but acetate is called ethanoic acid

So ethyl ethanoate this is what is represented by the -oate suffix that is given to the nomenclature

So the alcohol portion is given first space is given and the carboxylic acid portion is mentioned as -oate

So this is ethyl ethanoate this is the name of this compound suppose if you want to call this particular compound this compound I am specifically mentioning because this is a one butyl you have to number the position where the butyl group is attached it is attached to the first carbon

So it will be one butyl derivative not two butyl or other substituted derivative butanoate this molecule has a very pleasant flavor is banana flavor this is widely used in the perfumery industry and the food flavoring industry for example as a banana flavor that's why I mentioned this particular compound the point is that the butyl group is mentioned at the positional numbering corresponding to the attachment to the oxygen which is one position instead of two position or three position for example and it is a butanoic acid derivative

So it is butyl butanoate is the correct nomenclature for this particular systematic nomenclature of this particular compound C-O-X let us say for example C-O-Cl carbonyl acid chloride this would be oil chloride if you consider this this would be ethanol chloride butanol chloride and

So on the CN group is considered as a nitrile group for example this is a C5 derivative

So this is pentane nitrile which pentane nitrile this would be one pentane nitrile you can also have isomers of this this would be two methyl butano nitrile

So the longest chain is taken as the C4 chain the substituent is the methyl substituent it is a butyric acid derivative

So it is butano nitrile it will be two methyl butano nitrile because numbering starts from here

So it is specifically you need to mention pentano nitrile or butano nitrile and

So on properly by taking cyano group as part of the carbon chain in terms of the length of the chain that is being considered now an aldehyde functional group always ends up with a suffix all this is butanol you do not have to number the aldehyde because all the head chain aldehyde group always comes as the end of the chain

So butanol should be fine you do not have to say one butanol because there are no such thing as but two butanol if you consider the isomer of this then it would correspond to the two methyl substituted propanol

So this will be two methyl propanol

So the aldehyde substituent comes as the suffix all the keto functional group comes with the prefix oxo this is either called oxo or it is called own depending upon whether it is given the highest priority in the compound or it has a second priority I will give you two examples of this now let us say for example this is a ketone no other functional groups present in the ketone the longest chain is six carbon chain

So this is hexane on but then you have to mention where the carbonyl functional group is present in this particular system

So you have to say the position where the carbonyl functional group is

So this will be 2-hexanone one corresponds to the ketone the two corresponds to the position where the ketone is present in the long chain

So it is hexanone this is also a ketone it has a substituent

So if you consider the nomenclature numbering starts from here closest to the substituent

So this is a hexane 2-one but there is a functional group in the two position

So this would be two chloro hexane you do not need hyphen here two chloro hexane connected together there is no gap here space between chloro and hexane is not there

So this would be two chloro 2-hexanone

So that completes the nomenclature of this particular compound

So here you are actually naming it as a ketone compound suppose if there is also a carboxylic acid present in the molecule then it has to be named as a carboxylic acid

So one cannot use the suffix -one for the keto under those conditions one would use oxo as the substituent let us take this example now this is a carboxylic acid very clearly

because the highest priority goes to the carboxylic acid it is a pentane carboxylic acid

So it is a pentanoic acid but then there is also a substituent present which is the functional group that is present in the position the position number goes in this fashion

So this is 4

So this would be four oxo pentanoic acid

So the correct nomenclature is four oxo pentanoic acid this would be the correct nomenclature of this particular molecule four oxopentanoic acid

So whether you use oxo or one depends on whether you are naming it as a ketone or if there is a higher preference to another functional group the oxo does not come into the picture because you do not name it as a ketone in this particular instance for example you have to name it only as a carboxylic acid

So pentanoic acid is the correct nomenclature for this but then you have to specify the ketone position as an oxo four oxo pentanoic acid is the correct nomenclature for this compound if it is an alcohol you call it as ol end it up with ol all let us say for example this will be methane all this would be ethan all this would correspond to two methyl sorry this would correspond to this is one methyl propane all i am sorry there is longest chinese butane

So this is butane two all is the correct nomenclature for this you have to worry about the nomenclature involving the longest chain

So the longest chain is the butane chain

So this is one two three and four

So the hydroxy is in the two position

So it is two butanol if you consider this molecule here the longest chain is a propane chain this is one two and three this is the longest chain here

So this would be two methyl propane to all position of hydroxy is indicated as two all because it is in the two position there is also a substituent which is a methyl substituent

So is two methyl propanol is the correct nomenclature for that particular compound

So systematic nomenclature of aliphatic compounds is what we have seen

So far aliphatic a cyclic compound is what we have seen

So far we can look at the cyclic compounds also this would be cyclopropane this will be cyclobutane cyclopentane for example cyclohexane

So you add the cyclo as the prefix and count the number of carbons and name it as that many carbon number this would be cyclo hexane

So the nomenclature is very similar to the propane butane pentane and

So on except the ene is added as cyclohexane this would correspond to cyclohexene

So the olefin is always ending up with the suffix which is the in suffix if it is an alkyne then you end up with y and e it is a triple bonded compound it will end up with yne in y and e let me give a couple of examples of that to illustrate the point we take this compound this is an acetylenic compound and it is a c7 chain

So it is a hepta you have to specify the position of the alkyne

So start from the position where the lowest number goes to the alkyne three iron

So this would be hepta 3 iron is the correct nomenclature for this particular compound if it is a olefinic compound this is a penta two in

So the yne and iron are the suffix for the alkyne and the alkyne type of compound if it is in the form of a cyclic system you write the number cyclo as a suffix as a prefix for example to the nomenclature this would be cyclohexene

So if you have to name this particular compound the alcohol gets the higher priority compared to the olefin and the alkene please remember that

So the numbering goes like this this will be cyclo hexane one all but it is not a hexane it is a hexane

So it is a cyclohex two in one all

So the correct nomenclature will be cyclo x two in one all this would be the correct nomenclature for this particular compound it specifies both the position of the unsaturation which is the double bond here which is in the two position with respect to the hydroxy the hydroxy itself is in the one position

So it is a hexane one all is the correct nomenclature for particular compound if you have to name this particular compound the this is always given as a suffix

So this would be chloro which chloro derivative this is one two three four this would be four chloro but two in

So that would be the correct name for this particular compound the yne comes to a higher preference compared to the chloro

So it is named as chlorobutene amine compounds are this is one two three four this is one butane amin or butane one amine also you can say butan one amine

So amine compounds are given as amine itself if you compare these two compounds here here

hydroxy gets the preference

So it is named one in the hydroxy and two in terms of the olefin but in this compound the preference goes to the olefin and chlorine gets the least

So this is actually three chloro cyclohexane that is the correct nomenclature

So pay attention to the preferences that are given to the functional group alkyl functional group phenyl functional group and

So on are getting the prefix with the lowest priority whereas functional groups like carboxylic acid hydroxy functional group would get higher preference compared to olefins and alkanes in the nomenclature system of nomenclature in case of aromatic compounds benzenoid compounds for example benzene one can write benzene like this or like this they are equivalent representation do not get confused this would be methyl benzene also known as toluene this is a 1,4-disubstituted benzene derivative

So this would be one ethyl 4-methyl benzene the substituent alphabetically this has a higher order compared to e comes before m

So this is given number one corresponding to ethyl e this is given four corresponding to m which comes at a later in the alphabetical series for example

So this should not be named as four ethyl one methyl toluene one methyl benzene this is a wrong nomenclature whichever substituent has alphabet that has higher priority in the alphabet series comes first and that is given the higher number compared to this if you consider this the numbering is given such that the lowest number goes to the sorry this is a four position

So this would be one chloro two four di-nitro benzene the other hand if you consider this compound this would be numbered as one two three four this would be two chloro four nitro one methyl benzene

So this is two chloro one methyl four nitro benzene that gives the substituents the lowest number and not the other way around it cannot be for example one chloro two methyl finite row that will give a higher number in terms of the functional group numbering compared to this particular number here phenyl is always taken as a substituent

So if you have to name this particular compound this would be one phenyl there are four carbon units one two three four one phenyl butane is the correct nomenclature for this particular compound we consider this particular compound this is pentane

So this is one two three

So one phenyl this is a bromo two three dibromo

So bromo comes first before two three dibromo one phenyl one two three four five pentane

So it is named as a pentane derivative with the bromine in the two and three position and phenyl in the one position

So it is two three dibromo one phenyl pentane is the nomenclature for that particular compound this compound is simply known as cinnamic acid colloquial name is cinnamic acid non-trivial name is cinnamic acid for example but if you have to name systematically this particular compound the numbering starts from here

So this would be three phenyl proper two in oic acid

So it is a propionic acid

So the position of the propionic acid is it two position propionic acid in the three position there is a phenyl group

So it is a propionic acid phenyl propane three two eight acid is the correct nomenclature for this how about a compound like aspirin let us take this simple compound which is acetyl salicylic acid acetyl salicylic acid is a trivial name this would correspond to two acetoxy benzoic acid in terms of the nomenclature that goes for this particular compound

So so far what we have seen is a systematic nomenclature of simple organic compounds now let us move on to the next topic namely the isomerism of organic compounds isomers are compounds having the same molecular formula but different structures iso means same mers means essentially the same building block is what is used in other words the molecular formula will essentially be the same and structurally they will be different the isomerism you can have structural isomerism where the structure itself is very different for different compounds that in the isomer series or you can have stereoisomerism stereoisomers the structure will be essentially same the connectivity in the three dimensional manner is different

So this is essentially same structure three dimensional connectivity is different the stereoisomers you have two types of stereoisomers one stereoisomer is known as the geometrical isomers the other one is known as optical isomer we will come to the

geometrical isomer and optical isomer little later

So the time being let us classify the structural isomers as chain isomers positional isomers functional isomers and finally metamers now if you consider a carbon chain which is containing five carbons you can have the carbon chain in a linear fashion like this this would be one possibility you can have a carbon chain which is going to be like this with a branching you can also have carbon chain which has two branching for example like this

So if you take a molecule of pentane which will be $\text{CH}_3\text{CH}_2\text{CH}_2\text{CH}_2\text{CH}_3$ you can have a normal pentane n pentane or you can have what is known as isopentane or finally neopentane molecular formula is same only the carbon connectivities are different

So that constitutes the chain isomers

So if you have more carbons in the chain the number of possible isomers also keeps going up because you can have branching at various positions for example you can have this is octane two four six eight there are eight carbons in this chain

So this is a octane this is an isomer of the same compound this is also an octane eight carbons are there but this is a highly branched octane

So this is called the iso-octane for example

So the chain isomer essentially arises because of the possibility of having substituent as a carbon

So the more longer the chain it is the more number of isomers that you can have in this particular pool positional isomers are essentially the position of the functional group will be different let us take for example a pentane chain or a hexane chain this particular case rendering heptane chain is what is taken if i put a hydroxy functional group here this will be heptane to all because the first position of the hydroxy functional group is in the two position suppose if i put the position of the hydroxy functional group in this position this will be heptane three all i can go to heptane four all also

So this particular position will be heptane for all

So all of this constitute the positional isomers in terms of the position of the functional group that is being present in the system

So if you consider similarly this is a two heptanone sorry two hexanone whereas this would be three hexanone

So you can have either two hexanone or two heptanone which corresponds to the positional isomers of the functional group that we are talking about functional isomers are isomers which have different functional group but the same molecular formula we consider these two molecule one is an aldehyde functional group other one is a ketone functional group both of them are C three carbon molecules only

So that constitute essentially the functional group isomerism in terms of the positional the type of functional group that is being present in the system if you take the alcohol and the ether for example these are also functional isomers one is an ether other one is an alcohol both of them have the same molecular formula for example if you consider a nitro compound a nitro compound can be this is an alkyl nitrite this is a nitro alkane So these also constitute the

So called functional isomers functional isomers are those where the functional groups are different otherwise essentially the molecular formula is same metamers when you have let us say for example two alkyl groups attached to a common atom like oxygen in this particular case you can have isomers of this kind this is diethyl ether whereas this is propyl methyl ether

So these are again isomers the position of the oxygen is different in the chain

So these are called metamers

So what we have seen in this particular lecture is the systematic naming of simple organic compounds using the iupac nomenclature method international union of pure and applied chemistry nomenclature method also we have briefly introduced the concept of isomers where the molecule has the same molecular formula but different type of structures examples are given for these four types of isomers that are present in the organic molecule we will deal with the geometrical isomer and optical isomer in the next slide next lecture thank you very much for your kind attention you