Coatings are everywhere but are paints coatings or coatings paints?

Why watching paint dry isn't boring!

Key Stage 4 Programme – 2016-2017

Teacher Name: Mrs Siyab

Pupil Name_____

Timetable and Assignment Submission

Fill this in with your teacher.

Timetable – Tutorials

Tutorial	Date	Time	Location
1			
2			
3			
4			
5			
6			

Timetable – Homework Assignments

Homework Assignment	Description	Due Date
Tutorial 1		
Tutorial 2		
Tutorial 3		
Tutorial 4		
Tutorial 5		

Assignment Submission – Lateness and Plagiarism

Lateness	
Submission after 4.00pm on **Put date here**	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

KS4 Programme 2016-17 – Pupil Feedback Report

Grade	Marks	What this means
1st	70+	Performing to an excellent standard at A-Level
2:1	60-69	Performing to a good standard at A-Level
2:2	50-59	Performing to an excellent standard at current key stage
3rd	40-49	Performing to a good standard at current key stage
Working towards a pass	0-39	Performing below a good standard at current key stage
Did not submit	DNS	No assignment received by The Brilliant Club

Lateness	
Any lateness	10 marks deducted
Plagiarism	
Some plagiarism	10 marks deducted
Moderate plagiarism	20 marks deducted
Extreme plagiarism	Automatic fail

Grade	**Marks**		
What this means	1st		
70+	Performing to an excellent standard at A-Level		
2:1	60-69		
Performing to a good standard at A-Level	2:2		
50-59	Performing to an excellent standard at current key stage		
3rd	40-49	**FINAL MARK / 100**	
Performing to a good standard at current key stage	Working towards a pass	**FINAL GRADE**	
0-39	Performing below a good standard at current key stage		
Did not submit			
No assignment received by The Brilliant Club			
Any lateness	10 marks deducted		
Plagiarism			
Some plagiarism	10 marks deducted		
Moderate plagiarism			
Extreme plagiarism	Automatic fail		
Grade			
What this means	1st		

Contents

Course Rationale	Page 5
Mark Scheme	Page 6
Glossary of Keywords	Page 7
Tutorial 1	Page 8
Tutorial 2	Page 13
Tutorial 3	Page 17
Tutorial 4	Page 21
Tutorial 5	Page 28
Appendix 1: Referencing	Page 32
Appendix 2: University Application Guidance	Page 33

Course Rationale

Materials are amazingly diverse with multiple functions. Some are hard, some are soft, and some are rigid whereas others are flexible but nonetheless all are fit for a purpose. Materials science and engineering provides a deep insight into why a material acquires certain properties and how these properties are useful for the intended application. In this course students will explore the application of modern analytical tools to analyse coil coatings and predict their service lifetime. They will gain knowledge about the use of coatings in the real world.

Coil coatings are similar to paint coatings applied to cars. They both are used to protect the underlying metal from corrosion. Coil coatings are commonly used for building panels amongst other applications. Due to this they are constantly exposed to extreme conditions such as; rain, humidity, wind and sunlight. These factors contribute to the degradation of the coating eventually causing it to breakdown. Therefore companies are required give guarantees on how long the coating will last. In order to predict the lifetime of the coating extensive research is carried out. Students will become familiar with some of the key techniques used to investigate coil coatings and learn the importance of in-depth research.

Mark Scheme

Key Skill	1st	2.2
Understanding of concepts	☐ Understands and explains the concepts beyond what is taught, indicating independent research.	☐ Understands and explains the concepts well.
Creativity	☐ Can help explain understanding of topic using own examples by either contributing to discussions or using them in written assignments.	☐ Can use the examples given in class and link them to different aspects of the course in either discussions or in written assignments
Reasoning	☐ Can use data or research to support and justify an argument.	☐ Can state the argument but it is not completely justified using proof.
Language and communication	☐ New vocabulary is correctly and appropriately used. ☐ Writing is well structured to support the theme of the essay ☐ Spelling, grammar and punctuation are used correctly.	☐ Use of some new vocabulary ☐ Good structure and flow in essay ☐ Spelling, grammar and punctuation are correctly used most of the time.
Research skills	☐ A range of reliable sources have been used ☐ Reference for sources has been given	☐ Used recommended resources ☐ Referred to information unique to tutorials but no reference given.

Glossary of Keywords

Word	Definition	In a sentence…

Tutorial 1 – An Introduction to Coatings

What is the Purpose of Tutorial 1?

- To understand the importance of coatings
- To become familiar with keywords and concepts associated with coatings
- To illustrate the composition and manufacturing process of a coil coating.

a)	b)	c)	d)
e)	f)	g)	h)

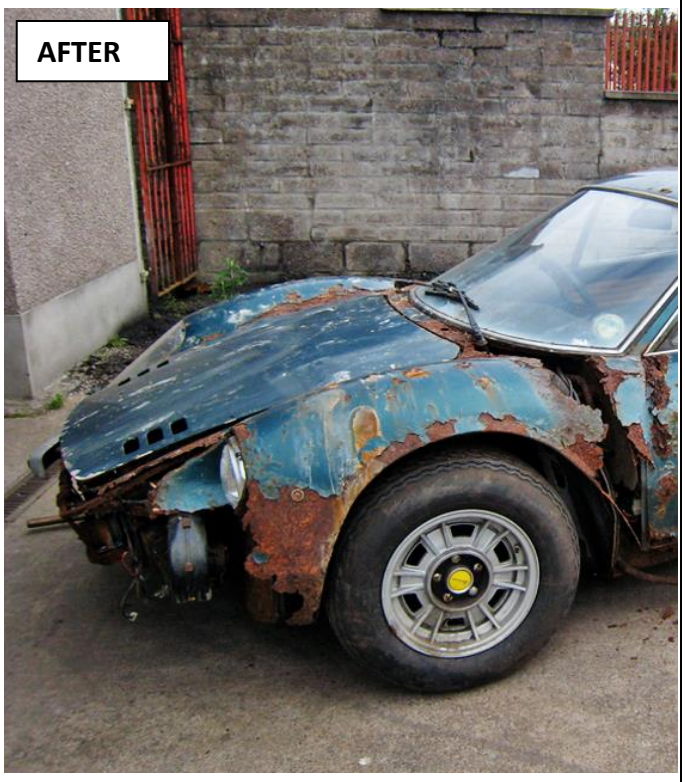


Figure 1: A before and after picture of the classic 1973 Ferrari.

DISCUSSION

Look at figure 1. What do you think happened to the body of the car in the 'after' picture?

Some points to discuss:
Does it look good? Does it look safe? How could you stop it from looking like that? How long did it take to get to that stage?

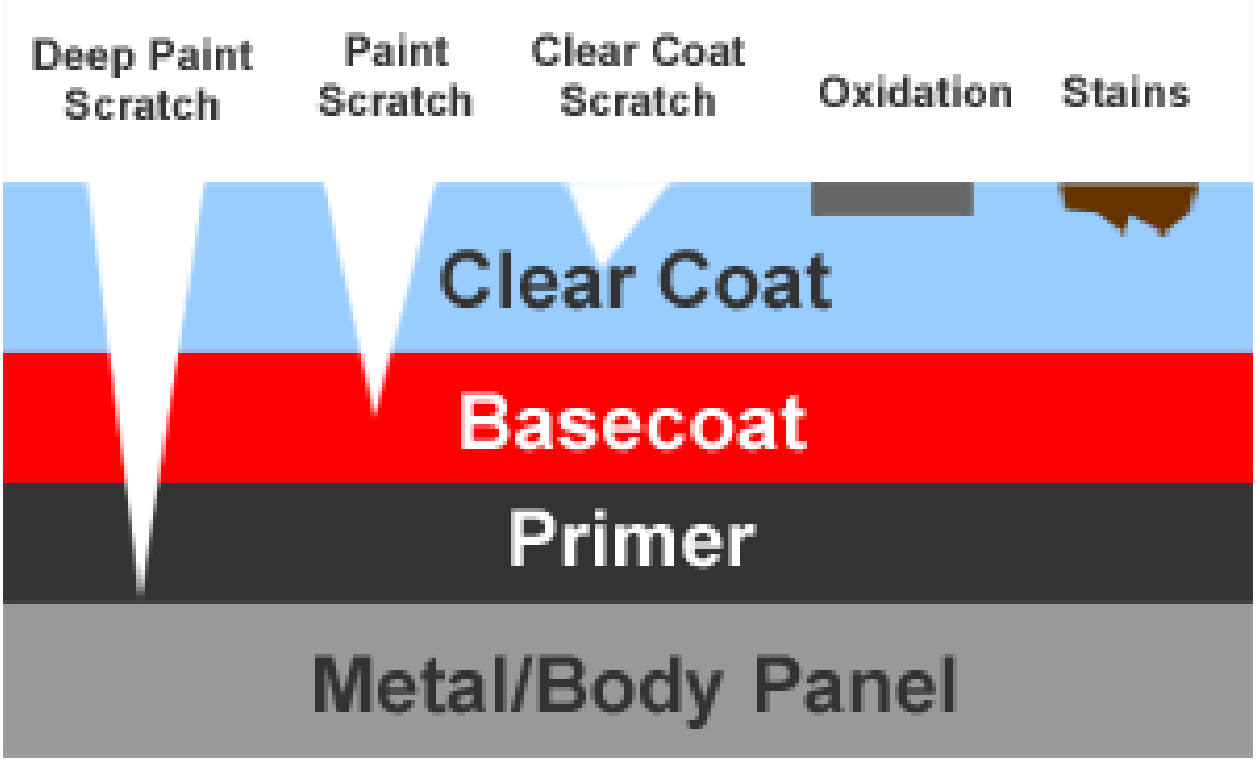
Discussion Notes:

➢ The purpose of a coating

The purpose of a coating is to protect the material it is being applied to regardless of the type of material used i.e. it could be wood, plastic, metal or any other material. The prime reason for using a coating may be to protect the material but it could have many other features. For example, the appearance may be something to consider, is it glossy or matte? Does it make the product look good? Is it the desired colour?

Could you think of any other reasons of why a coating could be useful?

How does the composition of a coating help protect the material?



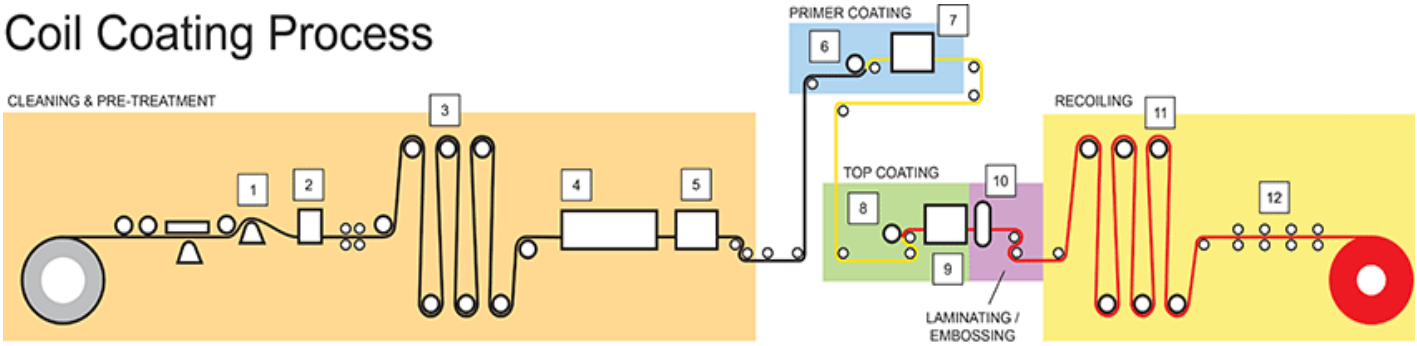
Notes

Key Question - How do you know which coating is better to use for a particular application?

Let us focus on a particular type of coating example. Questions that need to be considered are:
How is it made? What is the end application? How does the coating protect the material? How long will the coating last? What causes the coating to eventually break down?

COIL COATINGS

Coil coatings inherit their name from the production method in which the substrate, typically a metal is covered in various coating layers in order to protect and extend the lifetime of the substrate. They have been used in a variety of applications such as commercial as well as residential building products including roofing and building panels since the 1940s (Gu et al, 2004 and Zhang et al, 2009). The main purpose of coil coatings is to act as a barrier for corrosion protection of the underlying material but they also commonly incorporate visual appeal such as texture and colour for interior and exterior finishes.



1. Bare metal is uncoiled
2. Coil splicing
3. Entry accumulator stack
4. Metal degreasing, cleaning, rinsing & chemical pre-treatment
5. Drying oven
6. Primer unit (one or both sides)
7. Curing oven
8. Coating unit - top coat applied to one or both sides
9. Curing oven
10. Laminating / Embossing (one or both sides)
11. Exit accumulator stack
12. Recoiling

Activity: Match keywords to meanings

Degradation	
Weathering	
A coil coating	
Sustainability	
Composition of a coil coating	
Durability	

CASE STUDY

After looking at the various factors which affect the performance of a coating it can be safely concluded that it is necessary to find out how long the coating will last.
Through this course we will focus on a single polymer coating. We will identify the standard which, a coil coating must comply with when used for an outdoor application, the different factors which may affect its performance and how the performance is measured.

Extension

Read the journal paper and highlight key words and statements that you think are critical.

Homework 1 – Baseline Test

The homework assignment for the first tutorial is a baseline test to see your initial level of attainment in this subject area. The assignment will test for some or all of the subject specific skills that are required later in the final assignment. However, it is shorter than the final assignment and is will be an introduction to the subject as well as a challenge!

Do not worry too much about doing 'well' or 'badly' on the baseline test, it takes into account the fact that you may not be familiar with the subject area. It is designed to help you and your PhD tutor identify where you are at the start of the programme and to help you measure your progress along the way.

Today's Homework is:

Find the answers to the following questions. You are encouraged to use textbooks and educational websites.

- What is a polymer?
- What is the 'degradation' of a polymer?
- What happens to polymers at high temperatures?
- What are the differences between thermoset and thermoplastic polymers?
- How many types of polymers are used for coil coatings? (EXTENSION)

https://www.nde-ed.org/EducationResources/CommunityCollege/Materials/Structure/polymer.htm

Extra marks will be awarded for those who complete the extension and are able to show in-depth research into coil coatings.
Make sure to reference all research.
https://www.coilcoating.org/

Tutorial 2 – Polymers, Coatings and Degradation

What is the Purpose of Tutorial 2?

- To review what polymers are (from home learning)
- To distinguish between degradation and weathering
- To outline the measureable effects of degradation.

Polymers

Examples of polymers

Activity – Fill in the blanks

Degradation

Degradation of polymers occurs in many ways. Watch the video and make notes.

What was the purpose of adding an additive?

- To extend the lifetime

Degradation type	Cause
Thermal	
Photo-oxidation	
Hydrolysis	
Any extras	

THINK – PAIR – SHARE

Can degradation be measured or tested?

Chemical / Thermal

Physical / Mechanical

Discussion Notes:

Our Coating Investigation

Our coating is a clear coating applied to a metal substrate to protect it from degrading. It is usually applied to metals that are used for outdoor applications such as building panels to extend the lifetime of the material of the building. The coating is exposed to extreme weather and conditions such as heat, wind, rain and humidity.

In this investigation we will see why this coating has been successful over many years. We will look into how the coating responds to outdoor exposure and the change in chemical structure of the coating along with the physical breakdown.

Today's Homework is:

- To read up on SEM and AFM (Handout to be given)
- Highlight and look up definitions of any new words, we will discuss them together in the next session.
- Use the space below to write notes or definitions.
- Once you have read the handout, describe each technique in your own words.

Extra marks will be awarded for write-up with reference to extra sources for research. Try to expand your knowledge of SEM and AFM and include your research in your write up.

Tutorial 3 – What does the surface tell us?

What is the Purpose of Tutorial 3?

- To analyse physical changes on the surface of the coating via scanning electron microscope (SEM) images
- To understand the concept of atomic force microscopy (AFM) and how it supports the SEM images.

Summary of home learning task

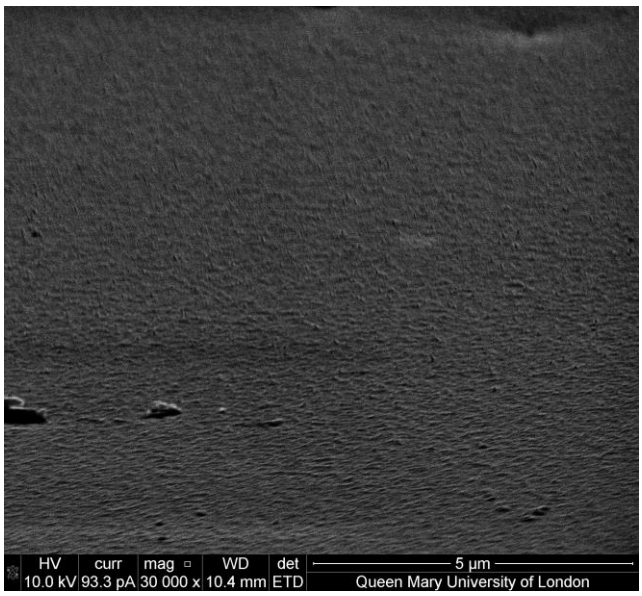
SEM is.....

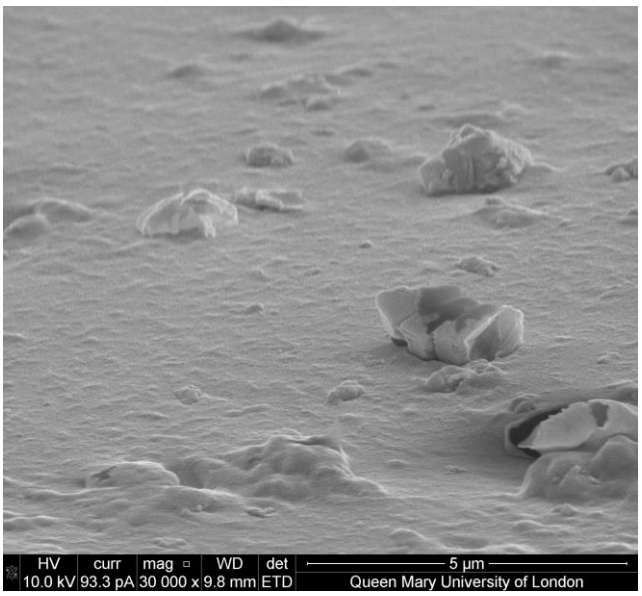
AFM is.....

Discussion

Look at the sample coupons. Can we see any changes on the surface of any of the samples? One is unexposed whereas the other one has been exposed to the weathering conditions as discussed earlier.

Activity – Look at the SEM images below. Match the SEM image to the correct coupon.





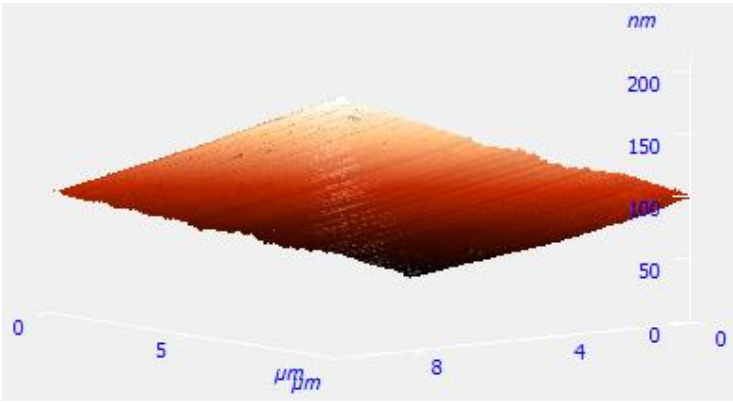
So far, we know that after exposure the coating begins to weather and therefore leading to degradation. Degradation can cause the coating to change physically and chemically. One of the physical changes that take place is on the surface of the coating. The surface becomes rough as the time of exposure increases.

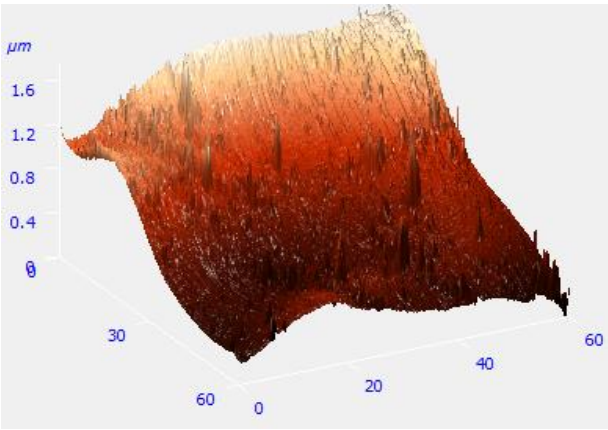
A quick recap of Atomic force microscopy (Watch video)

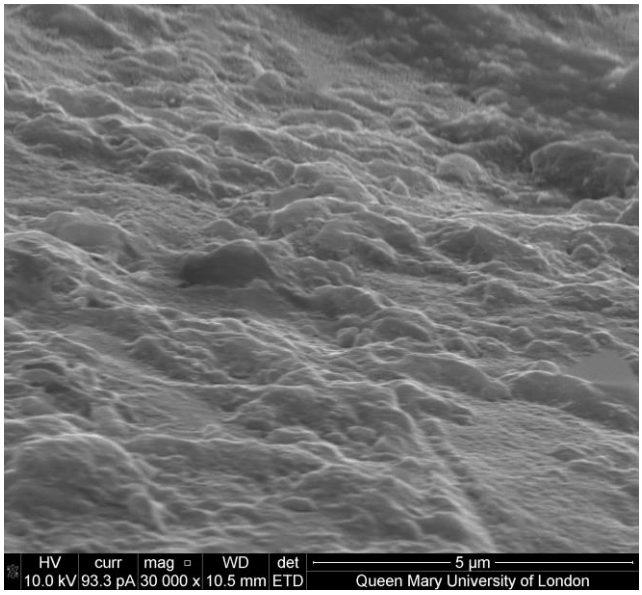
Activity – Circle the correct answer

1. Atomic force microscopy is also known as AFM / SEM.
2. It is a LOW / HIGH-resolution imaging technique.
3. It uses a LARGE / SMALL probe to with a sharp tip to scan back and forth over the surface.
4. The scanning is done in a CONTROLLED / UNCONTROLLED manner.
5. This measures the surface topography at up to ATOMIC / MICROMETER resolution.
6. In return this recreates the surface topography i.e. the ROUGHNESS / SMOOTHNESS.
7. The software enables us to view the surface as a 2D / 3D image depending on the settings chosen.
8. We CAN / CANNOT get numerical data to calculate a value for the surface roughness.

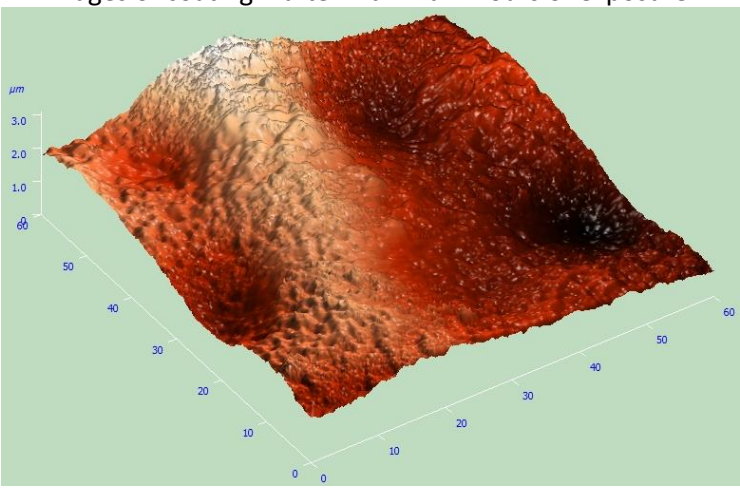
3D AFM images







Images of coating B after maximum hours of exposure



- Compare the extent of surface roughness to coating A

KEY QUESTION -How long does it take for the coating to degrade severely?
The degradation process takes many years before any significant changes can be seen on the surface. The AFM image shows a significant amount of change on the surface of coating A (the standard coating being investigated). However, this is still considerably better than coating B which, as can be seen has increased surface roughness in the same amount of time.

Advantages and disadvantages of SEM and AFM

Technique	Advantages	Disadvantages
SEM		
AFM		

Today's Homework is:

- To read up on Fourier transform infrared spectroscopy , FTIR (Handout to be given)
- Highlight and look up definitions of any new words, we will discuss them together in the next session.
- Use the space below to write notes or definitions.
- Once you have read the handout, describe thetechnique in your own words.

Extra marks will be awarded for write-up with reference to extra sources for research. Try to expand your knowledge of FTIR and include your research in your write up.

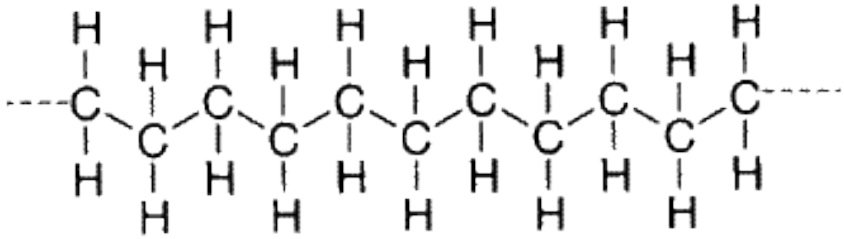
Tutorial 4 – Why are there changes in the surface?

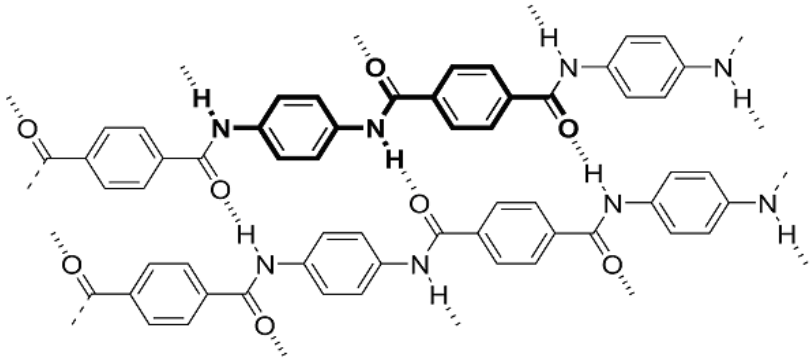
What is the Purpose of Tutorial 4?

- To understand how FTIR works and is used in detecting chemical changes in coatings
- To analyse chemical changes in coatings
- To analyse FTIR spectra and key wavenumbers of certain bonds for coatings

Activity: Use the space below to brainstorm what polymers are. Include any detail you know about the structure.

Polymer structure





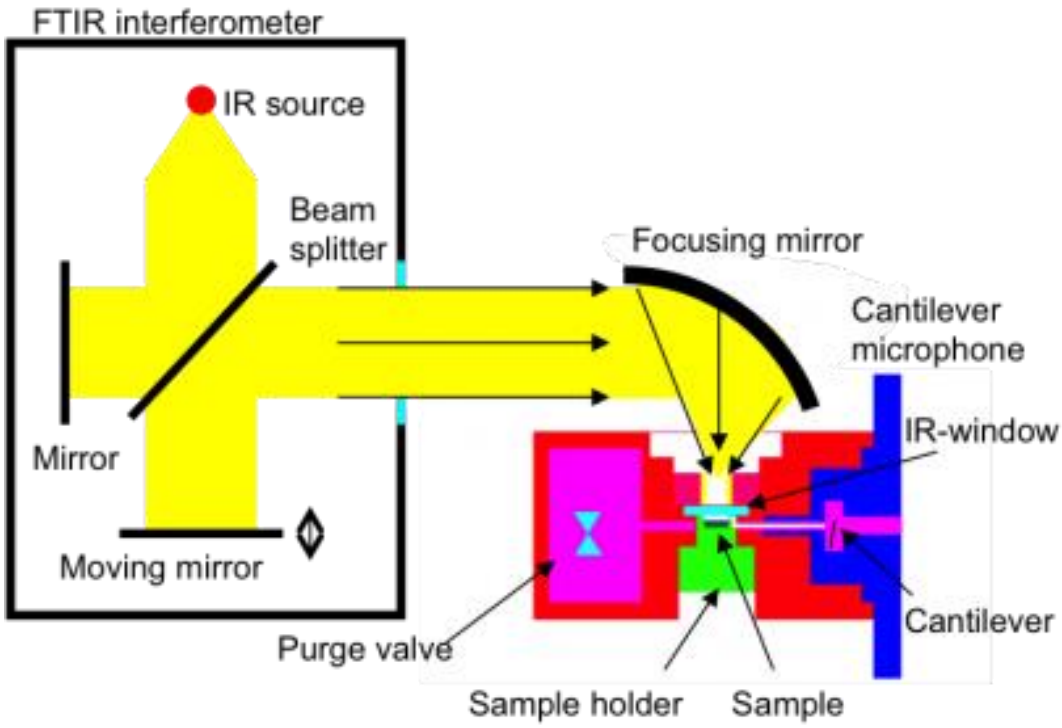
When a polymer molecule is attacked by free radicals or external factors different bonds are targeted. This is because each of the chemical groups have separate bond strengths and therefore require different amounts of energy to break them. Typically when degradation happens via photo-oxidation, long chain molecules are broken and as a result –OH groups are produced.
Fourier transform infrared spectroscopy (FTIR) can detect the vibration of these bonds.

Table 10.1 Typical vibrational frequencies of functional groups

Bond	Molecule	Wavenumber (cm^{-1})
C–O	Alcohols, ethers, esters, carboxylic acids, etc.	1300 – 1000
C=O	Aldehydes, ketones, esters, carboxylic acids	1750 – 1680
C=O	Amides	1680 – 1630
N–H (Stretching)	Amines and amides	3500 – 3100
–N–H (Bending)	Amines and amides	1640 – 1550
O–H	Alcohols	3650 – 3200
C–N	Amines	1350 – 1000
S–H	Mercaptans	2550

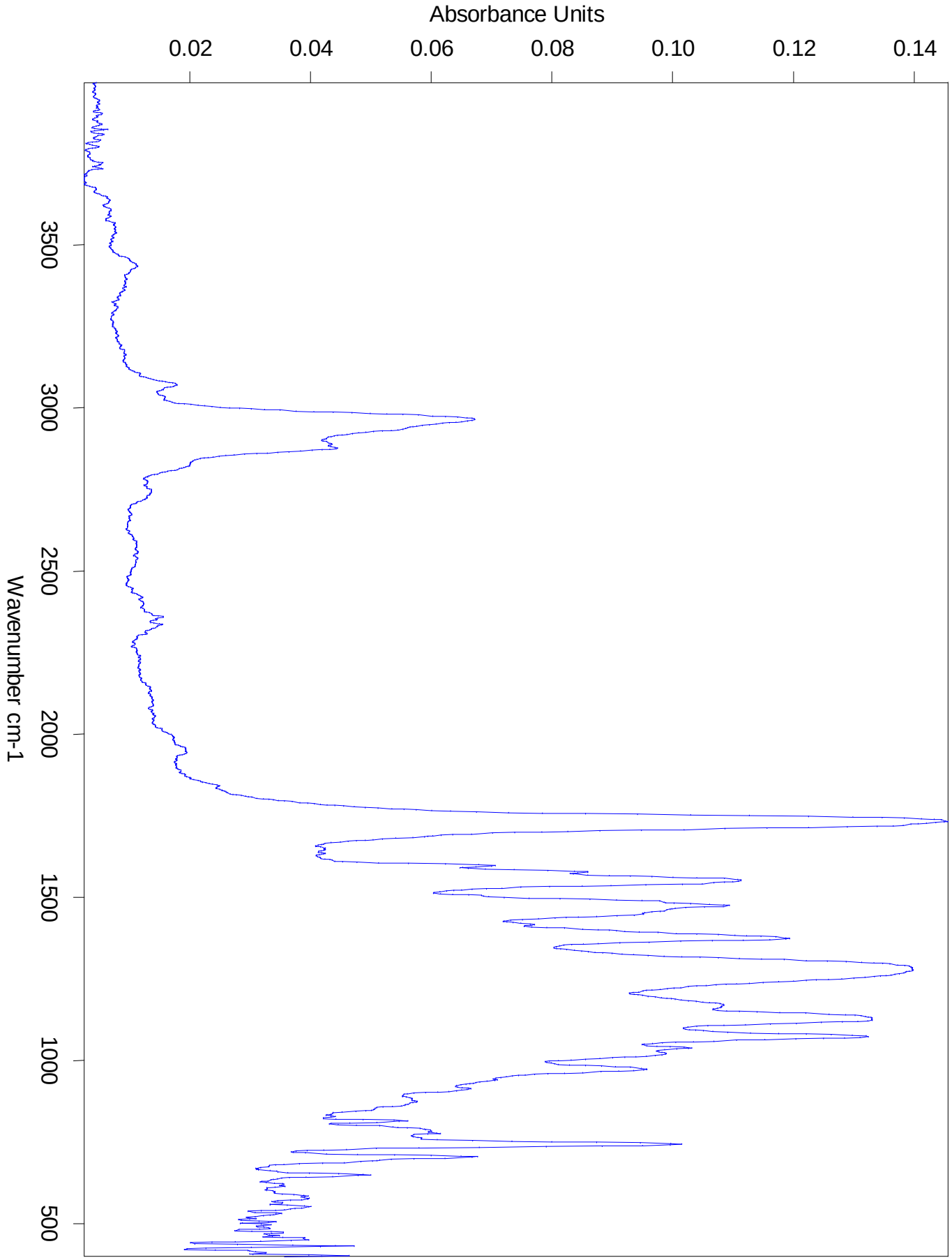
FTIR is used to analyse products in order to find their chemical make-up and perhaps the most significant analytical technique to examine degradation in coil coatings. FTIR is a popular method for analysing the chemical changes that take place with degradation as it examines both the coating and depth profiling of coil coatings. Photoacoustic FTIR (PA-FTIR) has been found to be a superior technique for following degradation of opaque (not transmitting materials) such as coatings with a conventional reflectance FTIR technique. This is because the latter relies in good surface physical contact between the germanium crystal and the sample for good spectral response, whereas the former is a non-contact technique. As samples degrade and their surface roughens, achieving good physical surface contact becomes more difficult and so the quality of the spectral response diminishes.

The Photoacoustic FTIR (PA-FTIR)

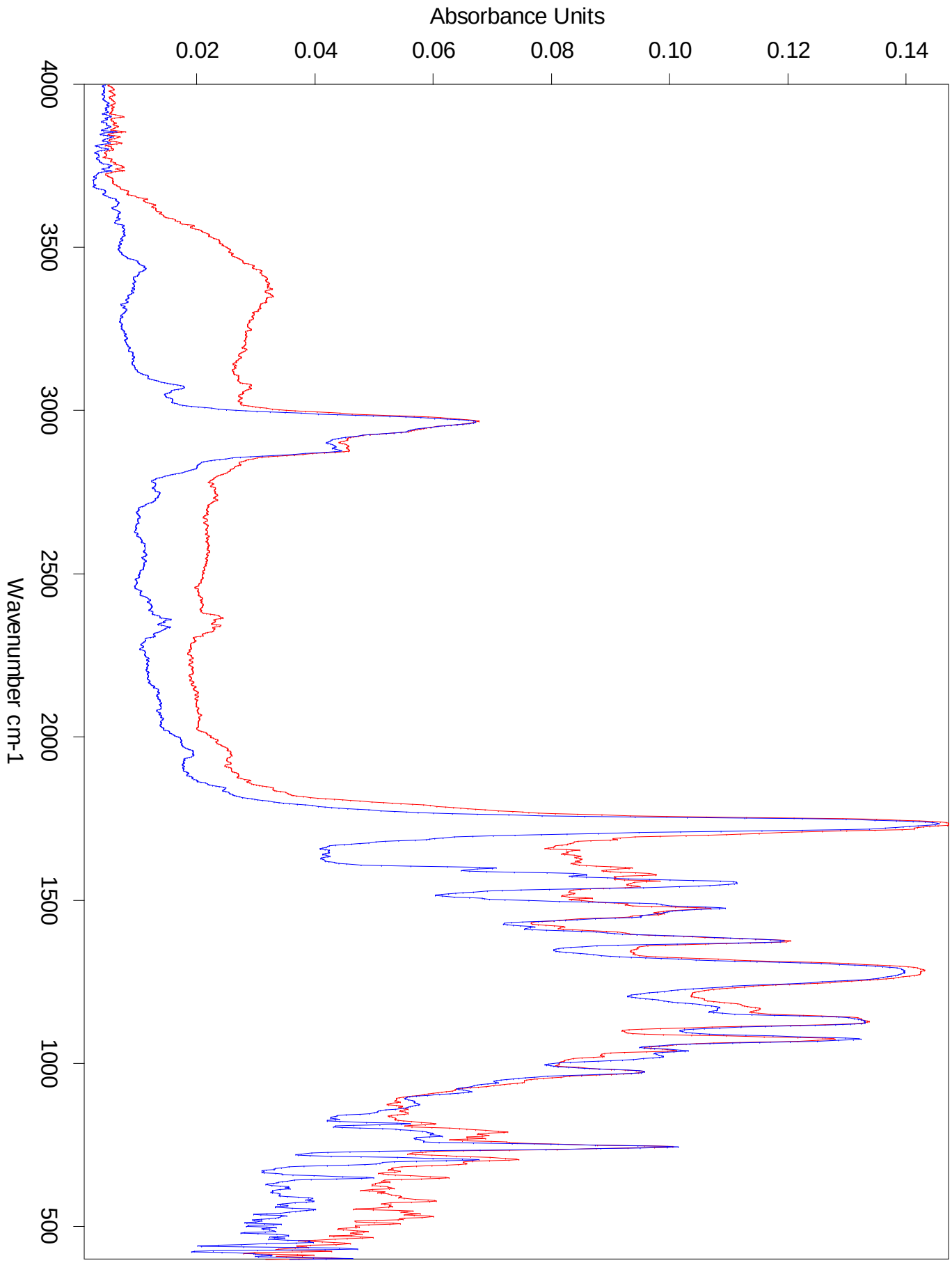


Notes:

FTIR Spectra

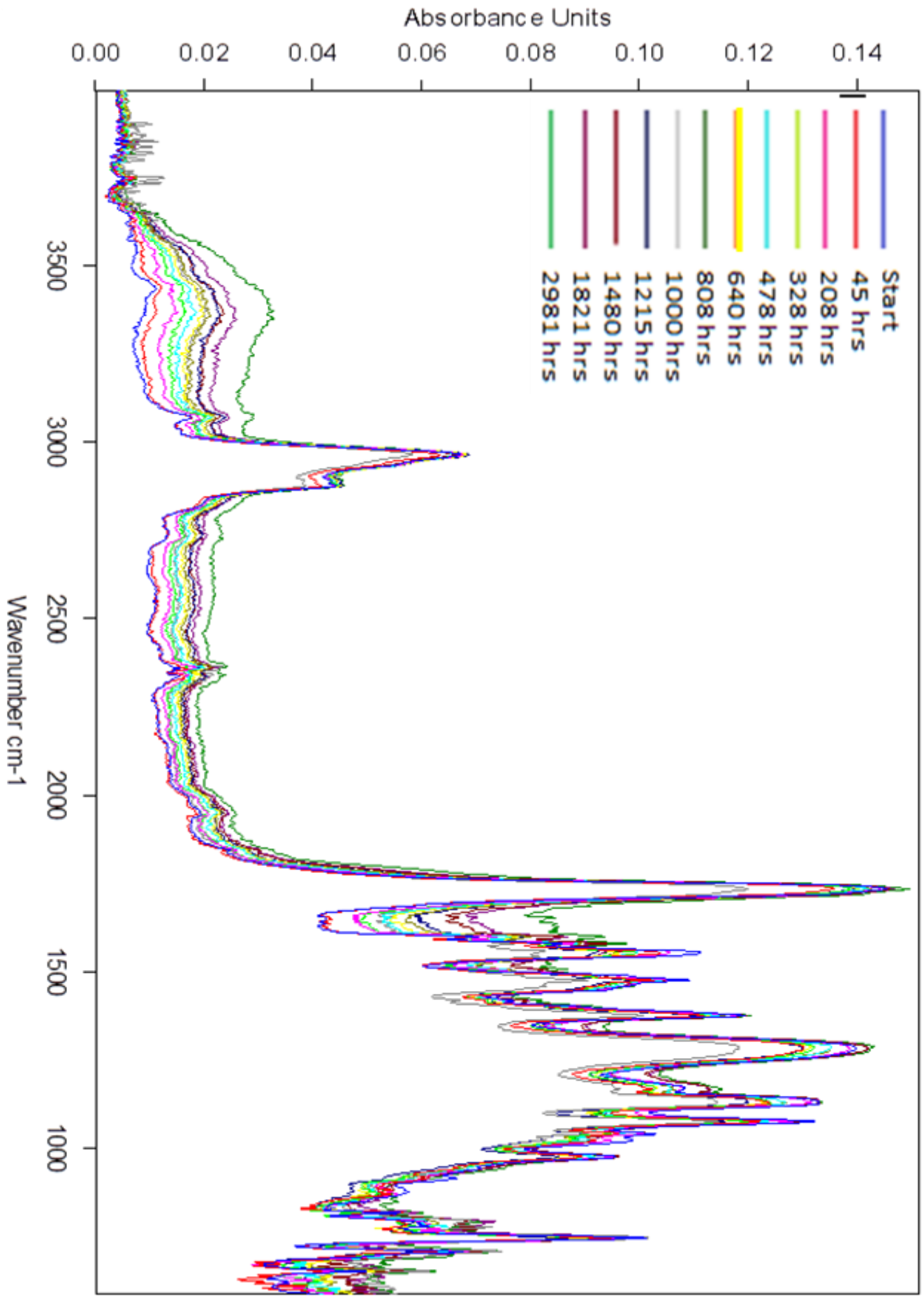


Coating A (unexposed)



Coating A (unexposed-blue and exposed –red)

Coating A exposed over time



Today's Homework is:

- For your final assignment you will be writing a mini essay on the importance of coatings with specific reference to the case study of coating A.
- Therefore this week's homework will be to write an introduction for the essay.
- The introduction should include:
    - The importance of coatings
    - Why they need to be analysed
    - The uses of coatings particularly as coil coatings
    - A brief outline to the applications of coil coatings
    - The materials used for coil coatings (a good chance to introduce polymers and use the information covered in the previous tutorials)
    - The problem of degradation which limits the lifetime of the coatings

You may want to plan what you want to put into your introduction and think about how you will link all the topics together.

Tutorial 5 – How does the information provided show me the bigger picture?

What is the Purpose of Tutorial 5?

- To learn how each technique can be useful in predicting the lifetime of a coating
- Discuss how the techniques can be used if new coatings were to be introduced in a company
  - What would be the key features to look out for?
  - Do we have data to compare it to?
- To know that research in any field requires fitting together small pieces of research to get a bigger picture of the problem and the solution
- To go through any area of the course in greater depth based on which one gathered most interest.

Today's Homework is: The Final Assignment!

The final assignment is a mini essay.

You have already written the introduction (include this into your final assignment)

Essay title: Come up with an essay title which describes the theme of your essay to the reader.
For example, 'Outstanding coil coating found for outdoor applications' or 'A highly competitive coating selected to use outdoors but is it the best?'

Essay theme: A company claims coating A performs very well for outdoor exposure. It withstands the weathering and the surface looks perfect even after many years. The coating is very strong chemically so it does not degrade significantly. Is this true?

Here are some questions which may help you in setting your argument.

- How are SEM, AFM and FTIR some of the key techniques to establish how well the coating performs?
- What can be said about polymers and degradation?
- If the coating is exposed outdoors can the conditions be controlled to limit the amount of weathering?

Your verdict

- Coating A proves to be a good standard coating for outdoor exposure but it does eventually degrade.
- Coating A is an outstanding coating therefore requires no improvement.
- Coating A is not good at all. Better coatings are already available.

Can you support your choice?

- Do results from the techniques used in previous tutorials help to support this claim?
- Do we have enough data to make this claim?

The assignment will be marked on the layout of the essay, the understanding of the concepts learnt during this course, the use of the data provided to support your argument as well as the use of extra references and finally for referencing any quotes used.

Bonus marks will be available for incorporating any extra but relevant research on coil coatings or the research techniques to support your argument.

Good luck!!!

The Deadline is:

2 weeks from today _____

Additional notes:

Tutorial 6 – Feedback

What is the Purpose of Tutorial 6?

- Reflect on skills learned on the programme with a view to encouraging resilience
- Receive feedback on final assignment

What are the key questions?

- What strengths have I demonstrated in my work and what areas of development are there left for me to address?
- What steps do I need to take to improve my academic output?

Activity 1 – Marking your own

Using the mark scheme, identify three things you did well and three things you could improve.

What went well?

1.

2.

3.

What could be improved?

1.

2.

3.

Activity 2 – Responding to feedback

Read through your feedback sheet and highlight on your assignment where you received positive feedback (one colour) and areas for improvement (different colour). You might find it helpful to annotate this with a brief comment or two.

Activity 3 – Looking Forwards: Think, Pair Share

1. Think about how you can use this feedback in your future school work.
2. Talk to your partner about how you both plan to make changes to your school work in the future as result of this feedback
3. Share your ideas as a group.

Appendix 1 – Referencing correctly

When you get to university, you will need to include references in the assignments that you write, so we would like you to start getting into the habit of referencing in your Brilliant Club assignment. This is really important, because it will help you to avoid plagiarism. Plagiarism is when you take someone else's work or ideas and pass them off as your own. Whether plagiarism is deliberate or accidental, the consequences can be severe. In order to avoid losing marks in your final assignment, or even failing, you must be careful to reference your sources correctly.

What is a reference?

A reference is just a note in your assignment which says if you have referred to or been influenced by another source such as book, website or article. For example, if you use the internet to research a particular subject, and you want to include a specific piece of information from this website, you will need to reference it.

Why should I reference?

Referencing is important in your work for the following reasons:

- It gives credit to the authors of any sources you have referred to or been influenced by.
- It supports the arguments you make in your assignments.
- It demonstrates the variety of sources you have used.
- It helps to prevent you losing marks, or failing, due to plagiarism.

When should I use a reference?

You should use a reference when you:

- Quote directly from another source.
- Summarise or rephrase another piece of work.
- Include a specific statistic or fact from a source.

How do I reference?

There are a number of different ways of referencing, and these often vary depending on what subject you are studying. The most important to thing is to be consistent. This means that you need to stick to the same system throughout your whole assignment. Here is a basic system of referencing that you can use, which consists of the following two parts:

A marker in your assignment: After you have used a reference in your assignment (you have read something and included it in your work as a quote, or re-written it your own words) you should mark this is in your text with a number, e.g. [1]. The next time you use a reference you should use the next number, e.g. [2].

Bibliography: This is just a list of the references you have used in your assignment. In the bibliography, you list your references by the numbers you have used, and include as much information as you have about the reference. The list below gives what should be included for different sources.

Websites – Author (if possible), title of the web page, website address, [date you accessed it, in square brackets].

E.g. Dan Snow, 'How did so many soldiers survive the trenches?', http://www.bbc.co.uk/guides/z3kgjxs#zg2dtfr [11 July 2014].

Books – Author, date published, title of book (in italics), pages where the information came from.

E.g. S. Dubner and S. Levitt, (2006) *Freakonomics*, 7-9.

Articles – Author, 'title of the article' (with quotation marks), *where the article comes from* (newspaper, journal etc.), date of the article.

E.g. Maev Kennedy, 'The lights to go out across the UK to mark First World War's centenary', *Guardian*, 10 July 2014.

Appendix 2 – University Applications Guidance

For course choices and careers information: www.brightknowledge.org.uk

For information and statistics on universities and course: www.unistats.direct.gov.uk

For comprehensive information on universities, including rankings:
www.thecompleteuniversityguide.co.uk

PLEASE NOTE – The Researchers in Schools programme is designed to support the university applications process at your school. The work you complete for the programme should add to your schoolwork rather than detract from it. Please be aware of deadlines and try to manage your workload appropriately. If you are worried about the

Subject Specific Top Tips for Strengthening an application?

Personalised handout to be provided depending on interest of each pupil