**QUIZ QUESTIONS, ANSWERS, NON-ANSWERS, for Course 5, “Charge Measurements & Papermaking”**

Session 1: INTRODUCTION

1A – A titration is required to determine which of the following quantities?

* Zeta potential
* Electrophoretic mobility
* Sign of charge
* Cationic demand

1B – What is the typical approximate pH range of acidic papermaking?

* 2.5 to 4
* 4 to 5.5
* 6 to 7.5
* 8 to 9.5

1C – About what proportion of carboxyl groups on a fiber surface will be dissociated (negative in charge) during alkaline papermaking?

* About 40 to 60%
* Less than 10%
* 65 to 80%
* Over 95%

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Session 2: Zeta Potential & Its Measurement

2A – What is formed when ions in solution are attracted to a charged surface, but they are also diffusing in all directions due to their thermal energy?

* A double layer is formed.
* All the ions are pressed against the surface.
* The ions all stay at the slip plane.
* Frictional heating occurs due to ion motions.

2B – When particles in a suspension of fine particles have a high and uniform absolute value of zeta potential, what words do use to describe the suspension?

* Colloidally unstable
* Coagulated
* Curdled or sedimented
* Colloidally stable

2C – Which of the following quantities is proportional to the change in measured electrical potential when a certain pressure is applied to an aqueous solution flowing through a pad of fibers?

* Charge density of the fiber surfaces
* Zeta potential of the fiber surfaces
* Electrical conductivity of the material
* Electrical resistivity of the material
* SCROLL TO THE BOTTOM TO SEE THE ANSWER KEY

Session 3: Cationic Demand & Its Measurement

3A – Which of the following is a common cationic (positive charge) titrant that is used for determination of cationic demand? (Hint: Its charge is not affected by pH.)

* Potassium salt of poly(vinylsulfate), i.e. PVSK
* Aluminum sulfate, which is called papermaker’s alum
* Cationic starch with tertiary ammonium groups
* Poly(diallyldimethylammonium chloride), i.e. PolyDADMAC

3B – What is the sign of charge of typical cellulosic fibers before any additives are used?

* Negative
* Near to zero
* Positive
* The sign is different for different wood types

3C – What’s a practical way to measure the cationic demand of a complete suspension of headbox stock, including the fibers in addition to fines and dissolved and colloidal substances (DCS)?

* Filter the sample and carry out of forward titration, just including the filtrate.
* Use the fiber pad streaming potential method and calculate the cationic demand from the zeta potential.
* Add a known excess of titrant, filter, then titrate the filtrate with the oppositely charged titrant.
* Increase the amount of toluidine blue-O dye gradually to the system until a color change is evident.

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Session 4: Streaming Current Endpoints

4A – When using the streaming current device for charge demand testing, what quantity will be proportional to the cationic demand of a sample?

* The signal shown on the device display when the sample is added
* The amount of titrant needed to achieve a “purple-pink” coloration
* The point at which a double layer has been fully developed on the plastic surfaces
* The volume of titrant when the signal from the device is zero

4B - Which of the following specimens would not normally be tested, in unmodified form, using the streaming current (piston-type) sensing device?

* Refined softwood fiber suspension (5% solids)
* Filtrate obtained from coated broke suspension
* White water (the process water drained during paper formation)
* Headbox furnish after removing the fibers with a screen

4C – Why is it not possible to reach the endpoint of a streaming current titration when the electrical conductivity is extremely high due to addition of monovalent ions?

* The salt ions greatly decrease charge interactions and also compete for adsorption sites on the plastic.
* The salt ions, depending on their charge, contribute to the cationic or anionic demand of the system.
* A high conductivity causes a malfunction in the electronics of the sensing device.
* The salt ions, at high concentration, interfere with the coloration of toluidine blue-O dye.

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Session 5: Dissolved & Colloidal Substances

5A – When the pH is below 3, about what proportion of the carboxylic acid groups on the fiber surfaces will be protonated (neutral in charge)?

* About half of them
* Almost none of them
* Almost all of them
* More information is needed

5B – Which of the following is usually the main contributor to the negative charge of papermaking fibers?

* Cellulose
* Hemicellulose
* Lignin
* Cationic starch

5C – What ionic species related to the use of aluminum sulfate (papermaker’s alum) usually has the highest positive valence?

* Aluminum hydroxide floc
* Cationic oligomers
* Sodium aluminate
* Trivalent aluminum ion (at pH 4 or below)

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Session 6: Optimizing Strength, Drainage, Sizing, etc.

6A – What value of “log of colloid titration ratio” gave the highest first-pass retention results when adding cationic starch to a papermaking furnish?

* Strongly negative, indicating a negative charge
* Strongly positive, indicating a positive charge
* No relationship between log CTR and retention
* Near zero, indicating a neutral charge

6B – What was the relationship found between wet tensile strength of paper and the electrophoretic mobility when adding different amounts of a cationic additive and an anionic strength additive?

* Highest wet tensile strength at positive electrophoretic mobility (i.e. zeta potential)
* Highest wet tensile strength at near-zero electrophoretic mobility (i.e. zeta potential)
* Highest wet tensile strength at negative electrophoretic mobility (i.e. zeta potential)
* No relationship between wet tensile strength and electrophoretic mobility (i.e. zeta potential)

6C – At the endpoint of a streaming current titration, to determine the cationic demand, what will likely be present in the solution phase, especially when the salt concentration is significant?

* Polyelectrolyte complexes with a neutral core, stabilized by the last-added titrant
* Completely neutral (1:1 stoichiometry) polyelectrolyte complexes
* An excess of the soluble polyelectrolyte that was added last (no complexes)
* A solution phase that is completely free of any titrant molecules

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Session 7: Control of Charge

7A – What is most commonly a main factor leading to variations in the amount of retention aid that is needed to maintain a constant value of consistency in the white water (tray water) of a paper machine?

* Large unexplained changes in the pH of the papermaking system
* Changes in the cationic demand of the process water
* Changes in the operation and efficiency of pulp-washing equipment
* Changes in the nature of the retention aid solution, including decomposition

7B – In the case of a feedback process control system based on charge demand titrations, where is the sensing point at which the charge measurements are made?

* The samples are collected at the same point as the addition of a charge-control additive.
* The samples are collected before the point of addition of a charge-control additive.
* The samples are collected both before and after the point of addition of a charge-control additive.
* The samples are collected after the point of addition of a charge-control additive.

7C – Which of the following contributions of charge demand to a papermaking system is likely to be most disruptive to smooth operation of the paper machine and uniform product attributes as a function of time?

* Intermittent addition of large quantities of coated broke
* High cationic demand due to peroxide bleaching of high-yield pulp, e.g. CTMP
* Variations in pH during operation of a paper machine in the presence of calcium carbonate filler
* Addition of retention aid at varying levels, with the goal of keeping the tray water solids constant

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Session 8: Troubleshooting & Product Development

8A – Why does the zeta potential often “revert” with the passage of time after the addition of a high-charge cationic polymer?

* Diffusion of the additive into the mesopores of kraft fibers
* Chemical decomposition of the cationic polymer
* Gradual diffusion of extractives to the outside of the fiber
* Steady erosion of the fiber surfaces, with release of material into the solution

8B – What kind of addition point will tend to minimize the migration of cationic polymers into the mesopore spaces within the cell walls of kraft fibers before forming the sheet?

* To the thick stock, where the proportion of cellulosic fines is not as high as later
* At the machine chest, so that the polymers can interact strongly with the fibers
* At the white water silo, giving the agent equilibration time with the water before it contacts the solids (at the fan pump)
* Relatively late in the process leading up to the headbox of the paper machine

8C – What kind of measurement can tell the product development technologist whether a cationic or an anionic retention aid might be more advantageous in combination with a certain type of furnish and a specific set of additives and dosage levels?

* Charge demand titrations with a streaming current endpoint (applied to the untreated pulp)
* Electrical conductivity measurements of the combined furnish (indicating effects of ions)
* Measurements of pH to be able to estimate the proportion of carboxyl groups in their charged, dissociated state
* Fiber-pad streaming potential (for zeta potential at fiber surfaces)

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QUIZ ANSWERS:

1A: A titration is required to determine the cationic demand.

1B: The typical approximate pH range of acidic papermaking is 4 to 5.5.

1C: Over 90% of carboxyl groups on a fiber surface will be dissociated (negative in charge) during alkaline papermaking.

2A: A double-layer is formed when ions in solution are attracted to a charged surface, but they are also diffusing in all directions due to their thermal energy.

2B: When particles in a suspension of fine particles have a high and uniform absolute value of zeta potential, we would call that suspension colloidally stable.

2C: The zeta potential is proportional to the change in measured electrical potential when a certain pressure is applied to an aqueous solution flowing through a pad of fibers.

3A: Poly(diallyldimethylammonium chloride), i.e. PolyDADMAC is a common cationic (positive charge) titrant that is used for determination of cationic demand. (Note that its charge is not affected by pH.)

3B: The sign of charge of typical cellulosic fibers before any additives are used is negative.

3C: A practical way to measure the cationic demand of a complete suspension of headbox stock, including the fibers in addition to fines and dissolved and colloidal substances (DCS) is as follows: Add a known excess of titrant, filter, then titrate the filtrate with the oppositely charged titrant.

4A: When using the streaming current device for charge demand testing, the volume of titrant when the signal from the device is zero will be proportional to the cationic demand of a sample.

4B: A 5% consistency (filterable solids) suspension of fibers would not normally be tested, in unmodified form, using the streaming current (piston-type) sensing device.

4C: It not possible to reach the endpoint of a streaming current titration when the electrical conductivity is extremely high due to addition of monovalent ions because the salt ions greatly decrease charge interactions and also compete for adsorption sites on the plastic.

5A: When the pH is below 3, almost all of the carboxylic acid groups on the fiber surfaces will be protonated (neutral in charge).

5B: Hemicellulose is usually the main contributor to the negative charge of papermaking fibers.

5C: Cationic oligomers related to the use of aluminum sulfate (papermaker’s alum) usually have the highest positive valence.

6A: Near zero, indicating a neutral charge, gave the highest first-pass retention results when adding cationic starch to a papermaking furnish.

6B: The highest wet tensile strength was observed at near-zero electrophoretic mobility (i.e. zeta potential)

6C: At the endpoint of a streaming current titration, to determine the cationic demand, polyelectrolyte complexes with a neutral core, stabilized by the last-added titrant, will likely be present in the solution phase, especially when the salt concentration is significant.

7A: Changes in the cationic demand of the process water are commonly a main factor leading to variations in the amount of retention aid that is needed to maintain a constant value of consistency in the white water (tray water) of a paper machine.

7B: In the case of a feedback process control system based on charge demand titrations, the sensing point at which the charge measurements are made is after the point of addition of the charged additive.

7C: Intermittent addition of large quantities of coated broke is likely to be most disruptive to smooth operation of the paper machine and uniform product attributes as a function of time.

8A: Diffusion of the additive into the mesopores of kraft fibers causes the zeta potential to “revert” with the passage of time after the addition of a high-charge cationic polymer.

8B: An addition point relatively late in the process leading up to the headbox of the paper machine will tend to minimize the migration of cationic polymers into the mesopore spaces within the cell walls of kraft fibers before forming the sheet.

8C: Fiber-pad streaming potential measurements (for zeta potential at fiber surfaces) can tell the product development technologist whether a cationic or an anionic retention aid might be more advantageous in combination with a certain type of furnish and a specific set of additives and dosage levels.