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Addition Of Poly-Electrolytes On Recycled Fiber For Paper Sheet Formation

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The availability of forest resources to industrialize first generation lignocellulosic products is a function of the forest policies of each country, nevertheless the world demand globalized trade in relation to fulfill paper products specifications for use, in correlation with a coherent world with environment, especially with the management of (urban or agroindustries solid waste, those materials present opportunities to use products lignocellulosic) second or "n" generation, , implying challenges as: aging or damage of this source of biomaterials, presence of contaminants or chemicals required in the previous generation to satisfy the properties of paper use, among others.

This paper studied the adsorption mechanism of four polyelectrolytes: polydimethyldiallylammonium chloride (poly-DADMAC) of high and low molecular weight and its effect on secondary fibers distribution during paper sheet formation. The information is useful in the design and structure of the paper when recycled fiber is involved, to find the contact time and polyelectrolyte concentrations to improve the consolidation of fibrous network. The study builds up on the implementation of the modified Langmuir model with the collision theory.


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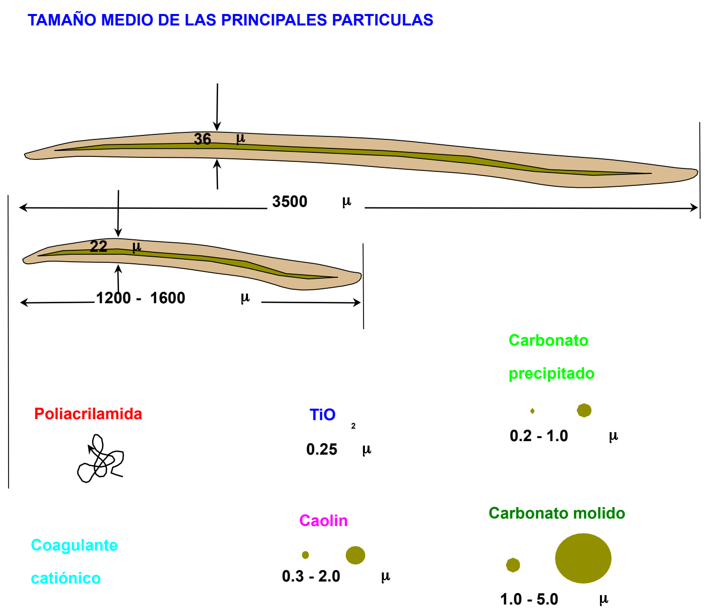
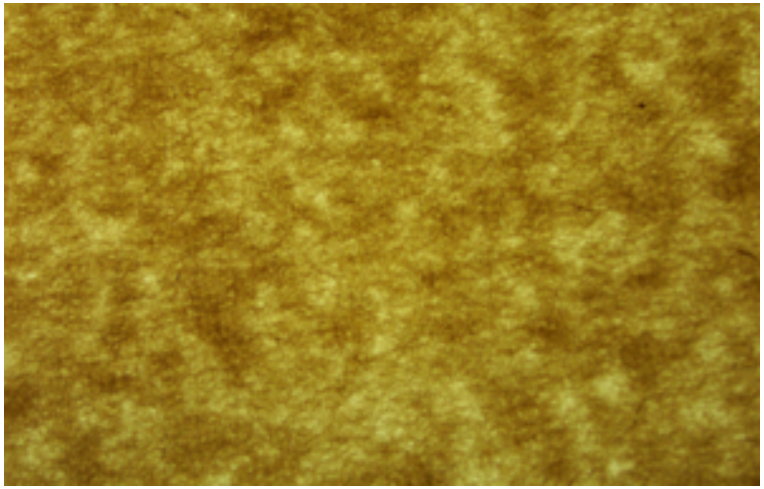
Background

Paper sheet formation is a continuous process, in which the cellulosic fibers, organic and inorganic fines and chemical additives consolidate a great three-dimensional network; on the basis of a mechanical intertwining of fibers and the chemical interactions between the various elements of the suspension fibrous



Background…cont

Paper sheet can be observed with a greater perspective on a smaller scale, based on: individual chemical flocs of fibers present in the consolidated structure, mechanical links and structures of the inner walls of fiber, microfibrils orientation on every wall, until to reach the α-cellulose molecule. Each of these levels directly influences on the paper structure and properties. For example: Uniform distribution of fibers into the structure impact on physical properties



Paper sheet with flocs

Theory

Paper sheet formation is a continuous process, in which the cellulosic fibers, organic and inorganic fines and chemical additives consolidate a great three-dimensional network; on the basis of a mechanical intertwining of fibers and the chemical interactions between the various elements of the suspension fibrous.

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Pèlach, M. À. and P. Mutjé (2012).- mechanical means of shear forces, flow velocity, turbulence, etc., y **Santos, I. R. d., G. Ventorim*, et al.*** (2014).- the presence of mineral fillers and fine particles of fibers (fines), which affect drainability during the consolidation of the network.

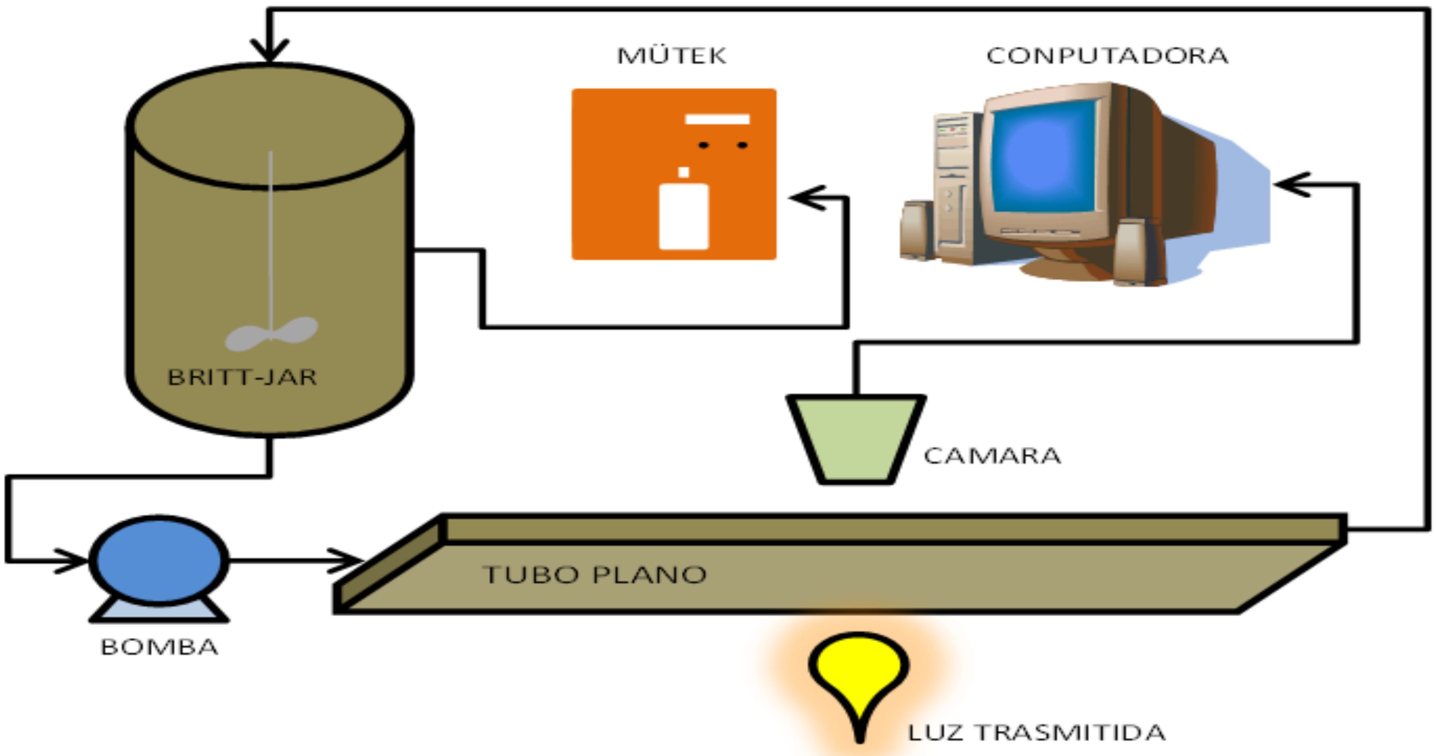
SU, Z.-h. and K.-t. HU (2005).- The principal function of the additives in fibrous suspension is retaining dissolved colloidal particles such as fine and inorganic fillers, furthermore, additives neutralize the dissolved ions in the aqueous system called anionic trash

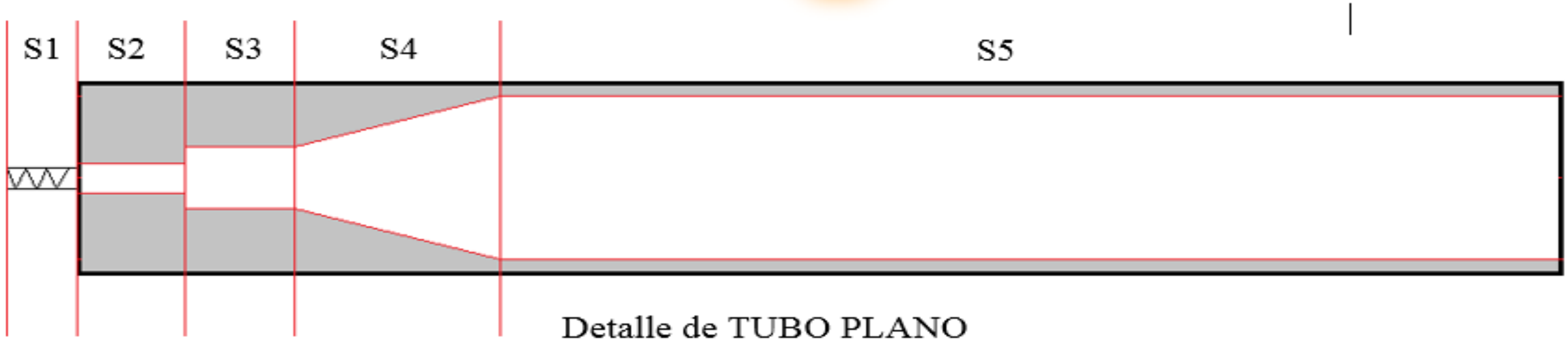
Cadotte, M., M. E. Tellier*, et al.* (2007).- The retention and neutralization is originated because of electrostatic charges of all components in fibrous suspension. Through these actions, the additives to be added to the formulation of fibrous

Experimental

1. The fibrous material used in this research was paper with a first cycle of use and paper with "n" cycles of use.
2. Analysis according to TAPPI techniques in its ash content (TAPPI T-211), moisture content (TAPPI T-412) and degree of drainability "Freeness" (TAPPI T-227).
3. Having determined these properties, a proportion of fibrous mixture was established for subsequent experiments involved in this research. The ratio of the mixture was 70 units fibers with n cycles of use and 30 units of first generation fibers
4. Four cationic polyelectrolyte were used: polydimethyldiallylammonium chloride (polyDADMAC), classified according to their molecular weight: high molecular weight Mw = 400,000-500,000 (ApM), medium molecular weight Mw = 200,000-350,000 (MpM) and low molecular weight Mw = 150,000-200,000 (BpM); the fourth polyelectrolyte Mw = 350,000-400,000 (CATIOFAST®111).
5. The adsorption kinetics was evaluated by polyelectrolyte titration using a particle load detector Mütek PCD 03. The fiber distribution was evaluated using an image analyzer composed of software Leica LAS suite V4 and stereomicroscopy MZ7,5 in a working area of 78.72 mm^2.

Experimental equipment





Detalle de TUBO PLANO

Results and discussion

The evaluation of the fibrous raw material outcomes are reported wherein difference shows between these different sources of fibers, ash content, refining degree, fiber length, fine, and Kink and Curl Index.

Table 1, Fiber characterization

Raw Materials	Fiber characterization						
	Moisture, %	Ash, %	CSF, ml	L, mm	IK, 1/ mm	IC,	Fines, %
First generation	4.8	0.83	650	1.8	0.74	0.06	15
"n" cycles	4.8	4.01	480	1	0.69	0.045	21

Results and discussion

The analysis of water used in the study is presented, it allows to evaluate the behavior of polyelectrolyte in the interaction with the ions from the process water.

Table 2, Initial evaluation of charge potential of the polyelectrolyte´s in presence of water

Ionic demand µeq L^{-1}		
Polyelectrolyte	Tap water	Deionized water
CATIOFAST	2163,65	1693,82
Low molecular weight, BpM	1951,58	1647,85
Mean molecular weight, MpM	1586,24	1612,52
High molecular weight, ApM	1372,64	1584,89

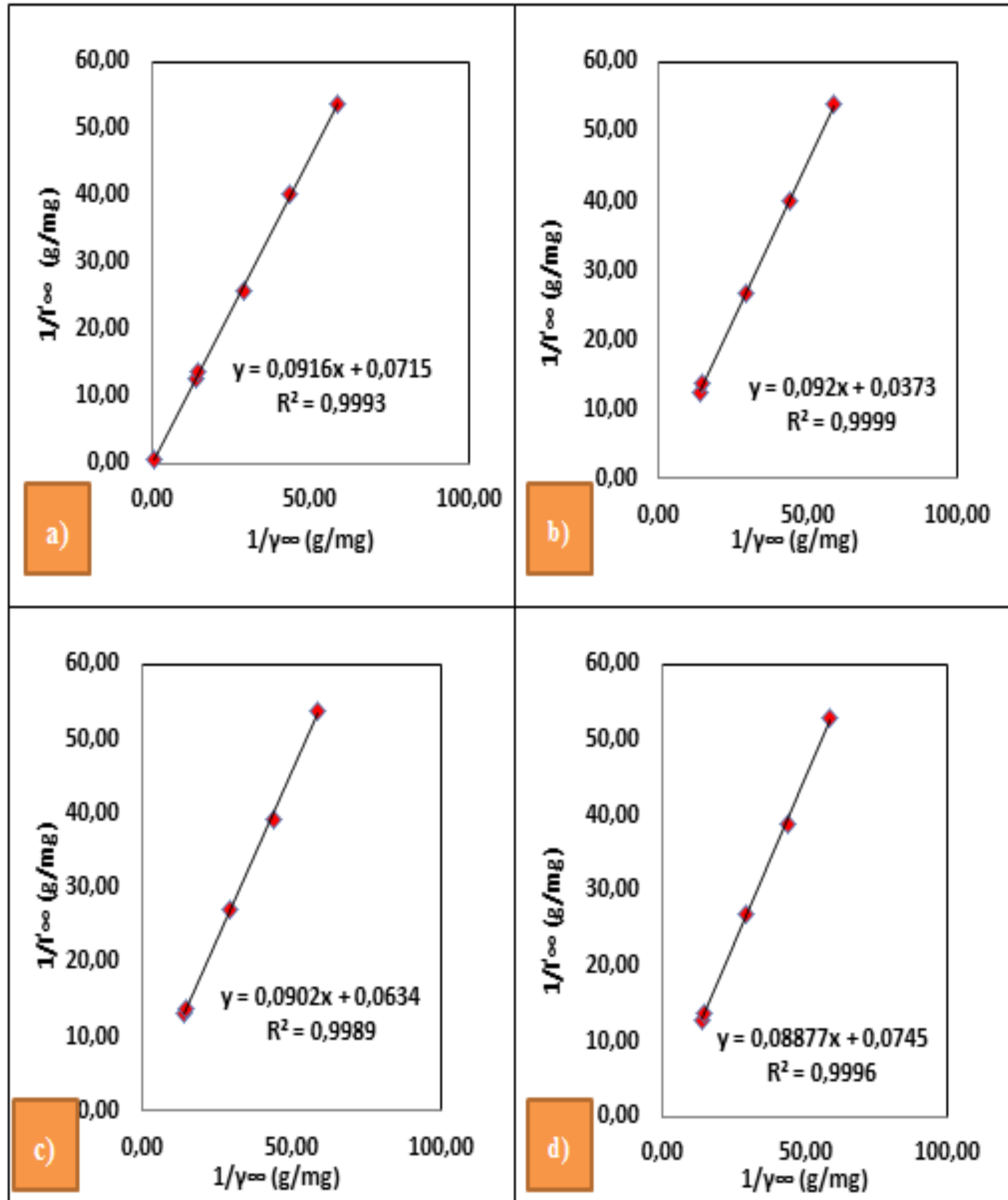
Results and discussion

According to analysis of variance for ionic polyelectrolyte demand was obtained the next information:

Table 3. ANOVA Table for neutralizing the ionic demand of the fibrous suspension by the addition of polyelectrolyte

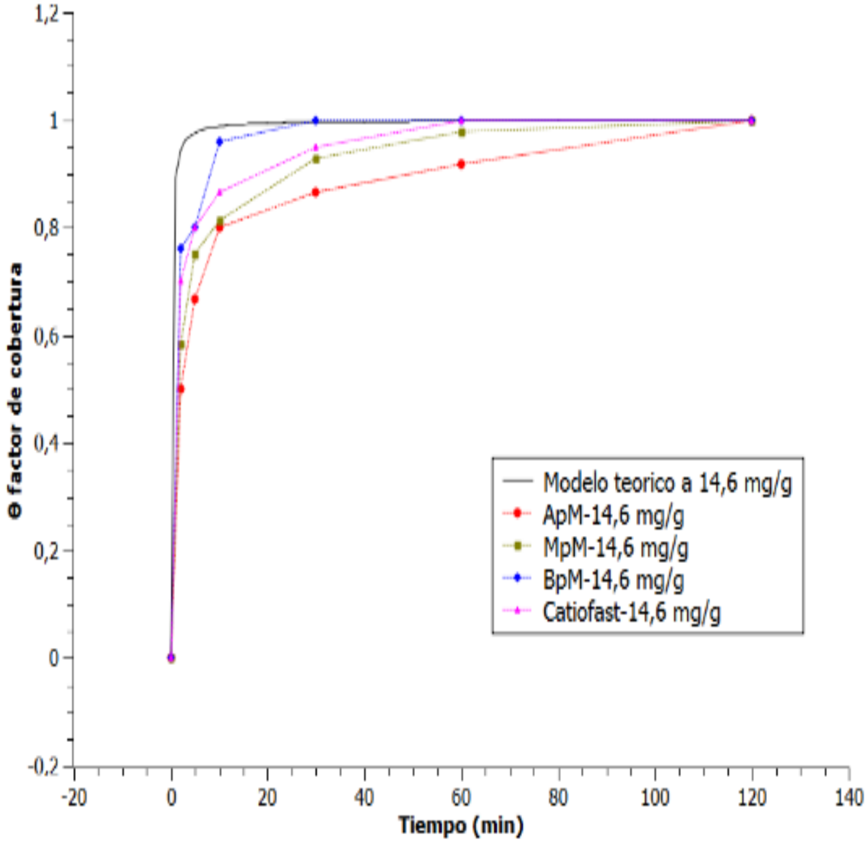
Source	Factors Sum of Squares	Gl	Mean Square	Reason-F	Value-P
MAIN EFFECTS					
A: Polyelectrolyte	242606,00	3	80868,5	1,69	0,3385
B: Kind of water	35806,21	1	35806,2	0,75	0,4507
RESIDUE	143555,00	3	47851,8		
TOTAL (CORRECTED)	421967,00	7			

Results of applying the linear model of Langmuir isotherms to the experimental data of the adsorption equilibrium of polyelectrolytes on fibers are presented in Figure 3. In this, it appears that the relationship between the inverse of the relative concentration of polyelectrolyte on fibers $(1/\Gamma)$ and the inverse of the value of relative concentration of polyelectrolyte $(1/\gamma_{\infty})$ have a good arrangement because in all R^2 were 0.99.



Results and discussion

Results with the theoretical model using experimental values of the coverage factor, here is generally notice that there is no good compromise between them. However, polyelectrolyte of low molecular weight (BpM) is the one most to approaches the theoretical model. In comparison to medium and high molecular weight.



The Surface Factor of coverage of polyelectrolyte on fiber as function of time

Results and discussion

The next four images shows: A) fibrous slurry; B) extension of irregularly distributed area (25X); C) Selection of the framework) D: quantifying irregularly distributed area. Regions with a greater flocs presence, a framework situated in the middle of the image (C) was established, in order to prevent disturbance of focus lens

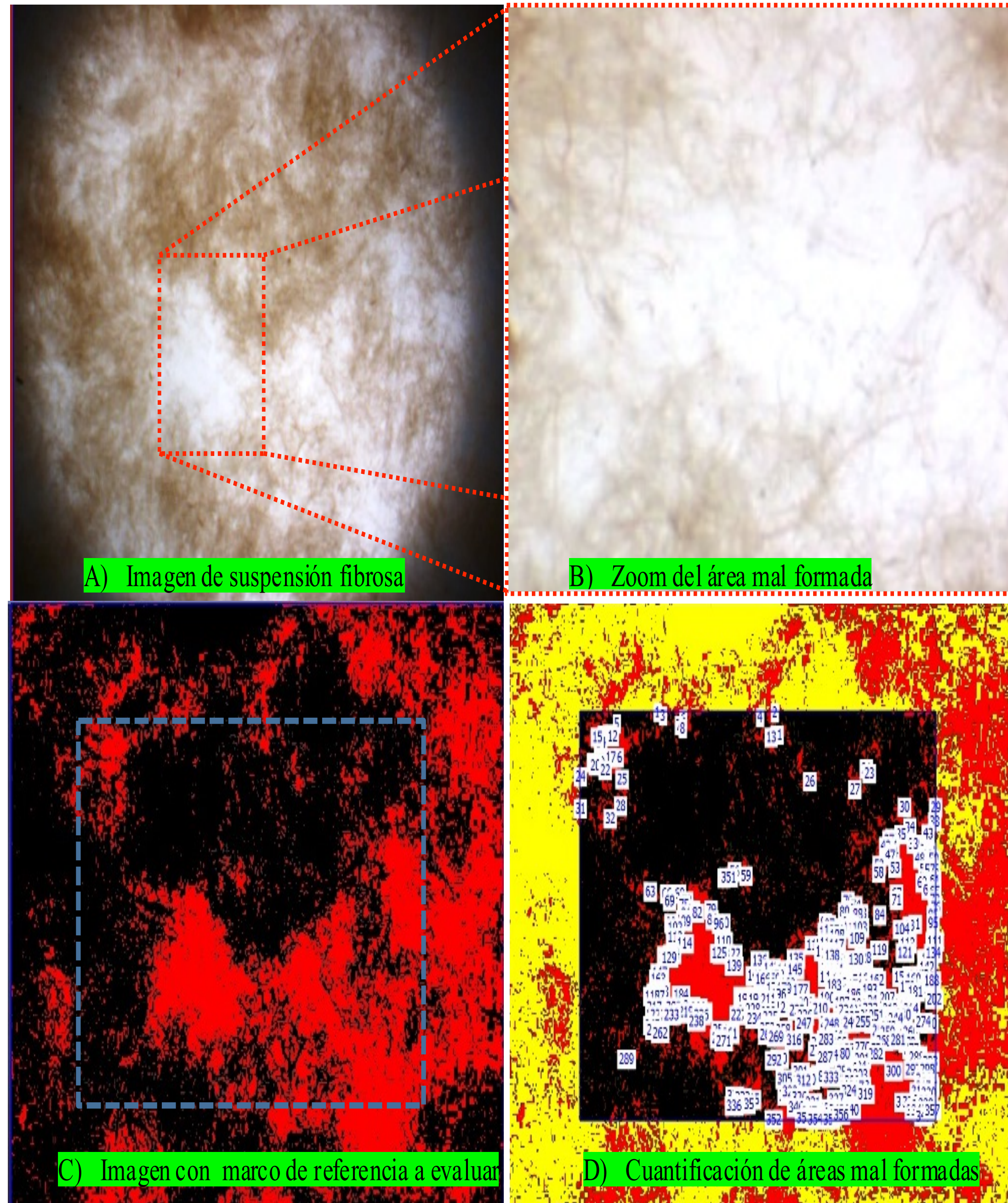


Figure 5, Outline the ajust process of parameters for image analysis

Conclusion

- In this study, the collision theory modified of Langmuir allowed describe the adsorption kinetics the polyelectrolyte on secondary fiber. This model does not take into account the impact of harmful substances such as anionic trash in the suspension.
- The distribution of suspended fiber showed a strong dependence by the molecular weight of the polyelectrolyte. In general, the best distributed area was found when low molecular weight polyelectrolyte is used, with respect to medium and high molecular weight polyelectrolyte´s when these were used.
- The results showed that the concentration of 14.6 mg g^{-1} of polyelectrolyte of low molecular weight (BpM) is sufficient for total coverage of the surface of fibers in 10 minutes of contact.
- ` The model reported that polyelectrolytes with higher molecular weight require more time to achieve the coverage of fibers.


I thank you for your attention