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Synthesis, characterization and rheological study of a polyelectrolyte polymer and its application in wastewater treatment

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ABSTRACT: The aim of this work is to synthesize a polyelectrolyte polymer (Polyvinyl alcohol (PVA)) through radical means and vinyl acetate as a vinylic monomer followed by hydrolysis. This includes its viscosity-mass which is well controlled. Its aim is also to optimize waste waters treatment of the purification station of the Galvacier Company (Kénitra), where the treatment is based on the process of coagulation/flocculation.
The synthesized polymer was characterized on the one hand by the use of infrared fourier transformation spectroscopy (IRFT), and on the other hand by the use of the viscometer to study its rheological behavior.
The result obtained concerning the micro- structural characterization confirms the structure of polyvinyl alcohol.
Processing the wastewater Samples through synthesized PVA enabled us to achieve attractive valuations on the physicochemical parameters of pollution waste water of the station. These results are translated into minimum values of the following parameters: 89 µS/cm.103 for electrical conductivity at 32 °C for temperature; 6,32 for the pH; 55,5 for the turbidity (NTU); 280 mg/l for suspended matter; 220 mg/l for the biochemical oxygen demand (BOD); 645 mg/l for chemical oxygen demand (COD) and 2.93 for COD/BOD report. Indeed, we found these results in an optimal dose equal to 0.2 g / l of this flocculating agent.

KEYWORDS: Polymer; flocculant; coagulant; Turbidity and PVA.

1 INTRODUCTION

Water is an essential element for most of the large companies of transformation, textile, slaughterhouses, galvanization... the use of the latter becomes a major source of pollution in case of non-treatment of the receiving milieu.

Several studies have focused on treating this type of wastewater using different methods among which we find the membrane separation, microfiltration, nanofiltration, adsorption and coagulation/flocculation [1], [2], [3]. In our case, we used the method of coagulation/flocculation [3] for the treatment of waste water (Galvacier).

During this work, we synthesized a polyelectrolyte polymer (PVA) [4], [5] by radical ways [6], using vinyl acetate as the vinylic monomer, followed by hydrolysis, whose viscosimetric study was determined.

2 MATERIALS AND METHODS

2.1 MATERIALS USED

In this work, we used first, the infrared spectroscopy with Fourier transformation for the identification of the structure of PVA, and secondly, we used the turbidimeter type HCAH2100, multi parameter Consort C535, apparatus of measuring COD type CR 2200 and the apparatus of measuring the biochemical demand of oxygen to evaluate the different physicochemical parameters of wastewater.

Viscosity measurements were performed using a viscometer Ubbelohd. The measurement conditions used are as follows:

- Viscometer size 1b for a series of dilution, capillary tube, constant K = 0.051493.

- Measurement Temperature in ° C: 30; 35, 40, 45, 50, 55 and 60

- Number of measurement: 2 each time

- Solvent: pure methanol

2.2 PREPARATION OF SAMPLES

To determine the viscosimetric behavior of standard PVA, we dissolved the polyelectrolyte polymer in pure methanol at different concentrations (5 %, 10 %, 15 % and 20 %). Next, we studied their viscosity by the capillary viscometer type Ubbelohd at variable temperatures going from 30 °C to 60 °C.

Fig.1. Apparatus viscometer

2.3 COAGULATION/FLOCCULATION PROTOCOL

The application of the method of coagulation/flocculation of the wastewater sample requires a prior optimization study of the pH of the medium, which led us to a pH value equal to 8, and the coagulant to the value 1g.

Quantities of synthesized PVA (0.1 g, 0.2 g, 0.3 g, 0.4 g and 0.5 g) were added to the reactional medium. Then, we added 1 g of oxygenated water in each container at the same temperature that we left under magnetic stirring (200 rev/min) for 5 min.

Finally, we reduced the stirring speed to 20 rev/min for 3 min before measuring the pollution parameters.

3 RESULTS AND DISCUSSIONS

3.1 CHARACTERIZATION OF POLYACETATE VINYL: AFTER HYDROLYSIS

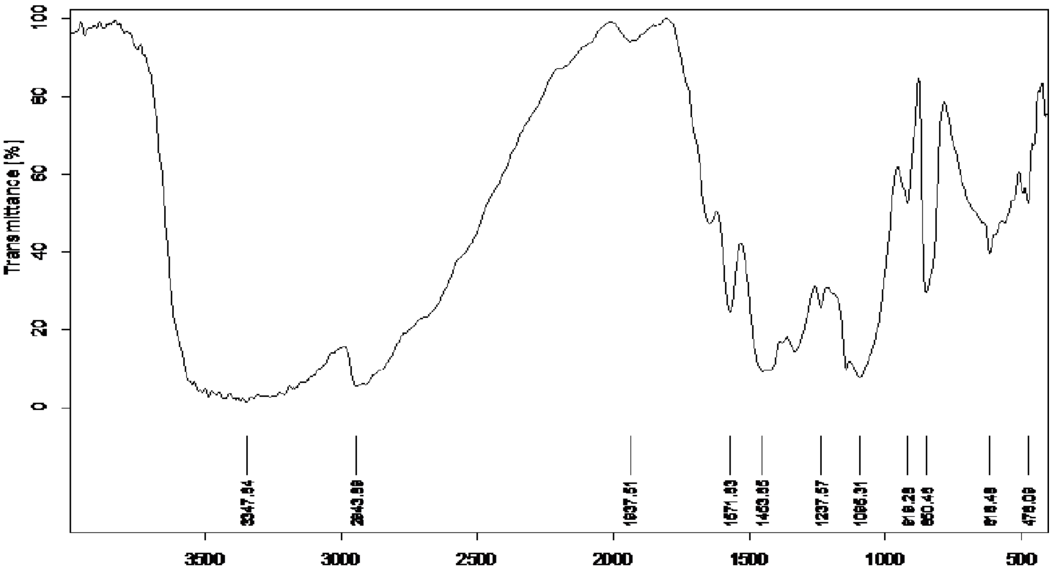

Fig.2. Spectrum of polyacetate vinyl obtained by Fourier Infrared Spectroscopy after hydrolysis.

IRFT spectra shown in Figure 2 showed us several bands among which are the band that lies at 2943.89 cm^{-1} corresponding to the CH bond of carbon SP^3, the band that lies at 1453.65 cm^{-1} corresponding to CH_2 group, the band that lies at 1085.31 cm^{-1} corresponding to the C-OH bond , the band that lies at 1571.83 cm^{-1} corresponding to the C-C bond and the band that lies at 3347.64 cm^{-1} corresponding to the OH function, which confirms the structure of the polyvinyl alcohol .

3.2 VISCOSIMETRIC BEHAVIOR OF POLYVINYL ALCOHOL (PVA)

The viscosimetric behavior study is done using a capillary viscometer of Ubbelohd type at varying temperatures going from 30, 35, 40, 45, 50, 55 and 60 °C.

The course of the viscosity variation according to the concentrations is shown below:

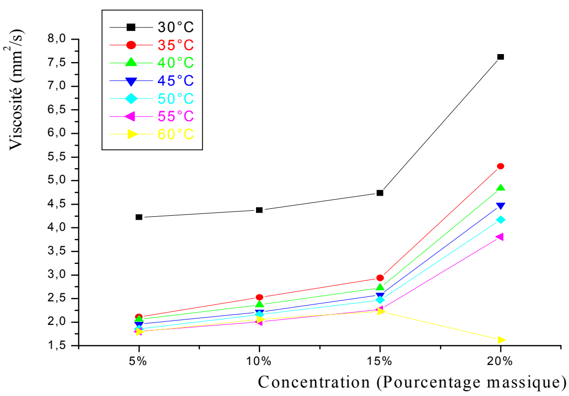

Fig.3. Variation of viscosity according to different concentration.

The results shown in Figure 3 are quite logical and expected. Indeed, the viscosity of the solution increases gradually as the concentration of PVA increases.

From 60 °C, the studied PVA goes from a viscous state to a liquid state, which explains the downfall of the observed viscosity.

3.3 APPLICATION OF PVA IN THE TREATMENT OF WASTEWATER

In this work, we tested the PVA as a flocculant to treat wastewater collected from the company Galvacier, Kénitra.

3.3.1 THE ELECTRICAL CONDUCTIVITY

The electrical conductivity is probably one of the most important parameters to control the quality of wastewater. It reflects the overall degree of mineralization that informs us about the salinity rate [7]. In Figure 4, we have shown the electrical conductivity according to PVA doses.

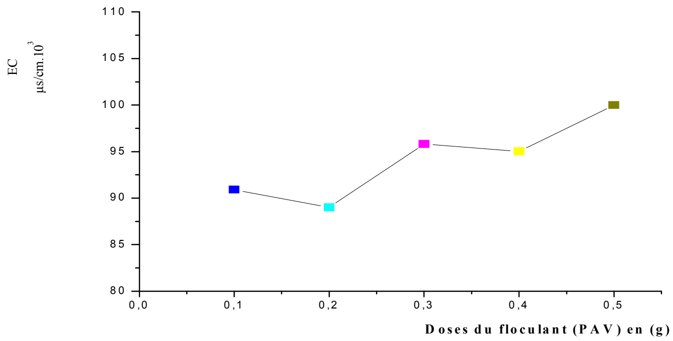

Fig.4.The evolution of the electrical conductivity according to PVA doses

From the curve of Figure 4, we found that the EC has decreased to a minimum value of about 89 µS/cm10^3. This value was determined at an optimum dose of flocculant 0.2 g PVA, which represents a large mass compared to the commercial PVA and / or ferrocryle [8].

3.3.2 TEMPERATURE

In Figure 5, we have represented the evaluation of the temperature according to PVA doses.

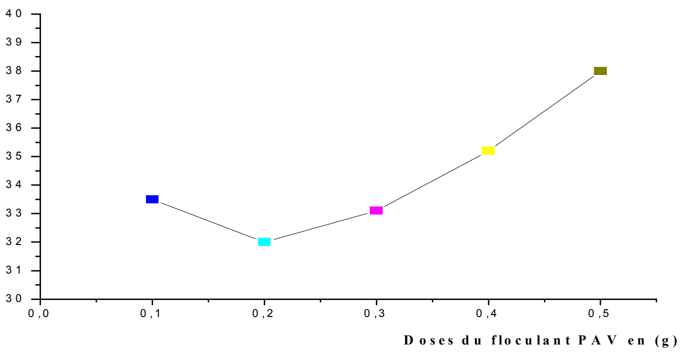

Fig.5. Evolution of the temperature according to the flocculant PVA doses

The Lowest temperature of the treated waters with the PVA flocculant was determined in the minimum value which has the order of 32 °C at a dose of 0.2 g of this flocculant. The average temperatures of wastewaters discharged by the galvanizing industry are between 30 °C [9] and 35 °C. The latter is considered as the limit value of the direct discharge into the receiving milieu [10].

3.3.3 THE pH CHANGE OF THE TREATED WATER

The curve in Figure 6 shows the variation in pH according to the PVA doses.

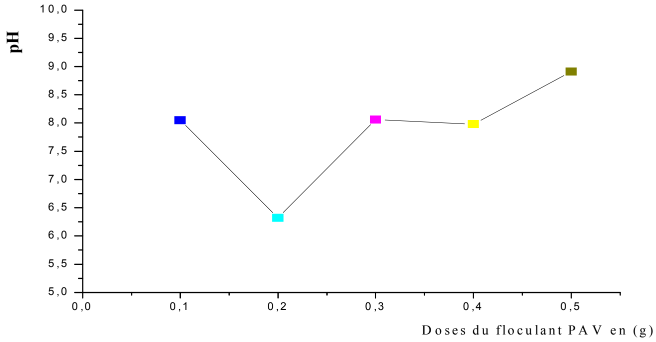

Fig.6. Evolution of the pH according to the flocculant PVA doses

From Figure 6, we found that the minimum pH is recorded in the value of 6.32 to an optimal dose of PAV equal to 0.2 g. For our study, the pH of the wastewater treated by the used flocculant is closed to neutrality.

3.3.4 TURBIDITY

The curve of Figure 7 represents the change in turbidity according to the PVA doses.

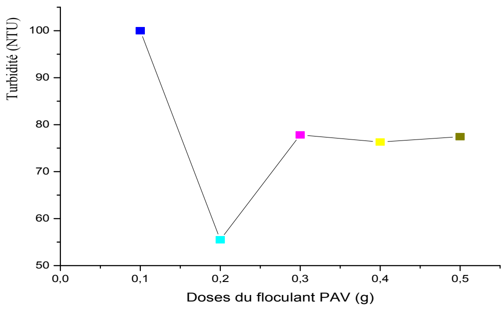

Fig.7. Evolution of the turbidity according to PVA doses.

The minimum turbidity of the water treated by the PVA has been recorded in the 55.5 NTU value to an optimal value of about 0.2 g as a dose of used flocculant. Thus the aspect of water has become very limpid.

3.3.5 SUSPENDED MATTER

Suspended solids represent the inorganic, organic and organometallic particles contained in the wastewater altogether [11]. The curve of Figure 8 shows the variation of the suspended solids according to the PVA doses.

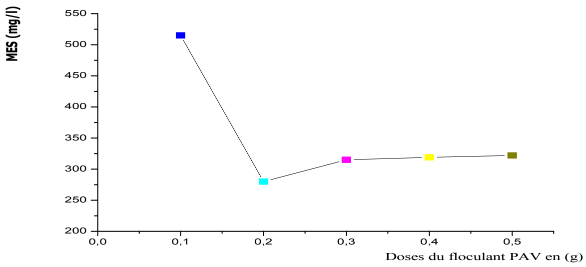

Fig.8. Variation Evolution of MES based doses of PVA.

From the figure above, we observe that the minimum value is recorded in 280 mg/l at an optimal dose of the order 0.2 g for the used flocculant (PVA).

3.3.6 THE BIOCHEMICAL DEMAND IN OXYGEN (BDO_5)

The figure below shows the variation of BDO_5 according to the PVA doses.

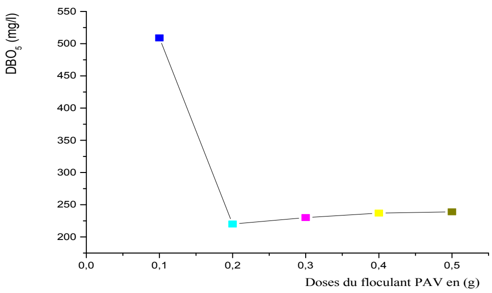

Fig.9. Evolution of BOD_5 according to the PVA doses.

The minimum value of the recorded BDO_5 is around 220 mg/l for an optimal dose equal to 0.2 g of PVA. This value is lower than the one specified in the norm of the limit values of the industry discharges (500 mg/l) [12], [13].

3.3.7 THE CHEMICAL DEMAND IN OXYGEN (COD)

The COD enables us to assess the concentration of inorganic or organic materials whether dissolved or in suspension in water, through the required amount of oxygen for the total chemical oxidation [10]. We have shown in Figure 10 the variation of the COD according to the PVA doses.

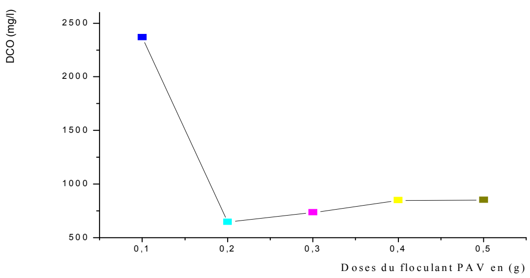

Fig.10. Evolution of the COD according to the PVA doses.

From the curve shown in Figure 10, we see the lowest value of the COD is recorded at 645 mg/l, for an optimal dose equal to 0.2 g of PVA. The Limit value of the direct discharge is 1000 mg/l [10].

3.3.8 The COD according to BDO$_5$

The relation COD/BDO$_5$ is relevant to the definition of the purification chain of an effluent. Indeed, the low value of the relation COD/BDO$_5$ implies the presence of a large proportion of biodegradable matters and allows to consider a biological treatment. Conversely, a large value of this ratio indicates that much of the organic matter is not biodegradable and, in this case, it is preferable to consider a physico - chemical treatment [10]. The relation COD/BDO$_5$ enables us to deduce if the directly discharged wastewaters into the receiving environment have the characteristics of domestic wastewater (the relation COD/BDO$_5$ less than 3) [9]. The results of this relation provide an indication of the importance of the polluting materials whether little biodegradable or not.

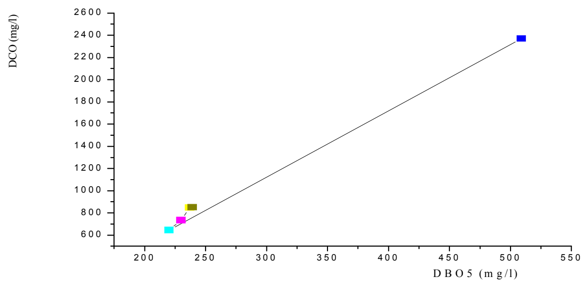

Fig.11. Evolution of the COD according to the BOD$_5$.

From Figure 11, we found the average value of the relation COD/BDO$_5$ is 2,93. It is consistent with that of wastewaters whose COD/BDO$_5$ is less than 3. So we can conclude that even if the wastewaters of this urban rejection provide a low organic load, they are relatively easily biodegradable.

4 Conclusion

Wastewaters of the galvanization company provide values of major physico -chemical parameters of pollution that relatively exceed the general value limits of direct and indirect discharges in the receiving environment (estuary of Sebou), which could create a risk of an environmental pollution for the latter. Hence the need for treatment of the wastewater is prior to its discharge into the receiving natural environment.

After assessing the degree of organic pollution, we can say that all the studied parameters (especially with BDO$_5$, COD and MES) localize the analyzed wastewater in a space whose physicochemical parameters have an average quality.

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