

## SYNTHESIS OF A "SANDWICH" SYSTEM BASED ON A POLYMERIC HIDROGEL COVERED WITH GELATINE TO IDENTIFY AMMONIUM AND AMMONIA IN COMPOST

Mejía V. H.<sup>1</sup>, Muñoz M. C.<sup>1</sup>, Flores M. J.<sup>1</sup>, Cortes O. J.<sup>1</sup>, Reyes G. I.<sup>2</sup>, Jiménez R. M.<sup>2</sup>,  
**Rentería U. M.**<sup>1(\*)</sup>

<sup>(1)</sup> Department of Chemistry

<sup>(2)</sup> Department of Chemical Engineering

Center of Exact Sciences and Engineering, University of Guadalajara, Jalisco, México, Boulevard  
Marcelino García Barragán 1421, CP 44420, Jalisco, México.

<sup>(\*)</sup>[reurmaite@yahoo.es](mailto:reurmaite@yahoo.es)

### 1. Abstract

The loss of nitrogen for volatilization of the gas ammonia ( $\text{NH}_3$ ) can be the principal reason of the low efficiency of some ammonia fertilizers in special situations as limy soils. It is the result of numerous chemical, physical and biological processes which ones depend on the pH, the capacity of cationic exchange, the organic matter, the temperature, the wind, the water evaporation of the surface of the soil and the quantity and way to apply the fertilizer. In this work it proposes the synthesis of an agar-gel composed by two physical gels; A and B, in which there are included two indicators capable of identifying ammonium and ammonia. Likewise, a sensitive to pH chemical hydrogel of itaconic acid was synthesized (AI). With that, we created a "sándwich" system close to the agar-gel. Using these systems is possible to control the process of degradation of the fertilizers in the lands of farm, identifying and quantifying the quantity of ammonium and ammonia. To evaluate the sensibility of the systems with regard to the pH and temperature, we carried out studies in laboratory conditions and in situ.

### 2. Introduction

Hydrogels are crosslinked three-dimensional networks of hydrophilic polymers that swell to sizes much larger than their original size in water without undergoing dissolution [1], [2]. Whereas in the chemical gels, the network is built with covalent bonds, very strong links which break suppose the degradation of the gel, in the physical gels, the unions are not completely stable, and generally are weak. For this reason, not only their properties but also their applications could be affected. In agriculture, these polymers (chemical gels), are using to increase the capacity of water retention of the soil, improving therefore, the growth of the plants [3], [4], [5]. Also these hydrogels are being exploited for liberation of nutrients [6]. The physical gels normally are using, in applications where is necessary less time of exhibition. They can be in use as temporary cover in sensors for volatile ammonia, helping to evaluate this concentration and also the fertilizers maturity. Great part of the nitrogen initially incorporated with fertilizers, does not recover with the crop, due to several things like filtration in the soil, volatilization and fixation of ammonia in the soil [7]. The process of volatilization, takes place in soils with pH

raised or in agricultural soils fertilized with urea or products that possess this compound. The solution could be the addition of less fertilizers with major frequency. For this, it is necessary to have a system to identify and quantify the volatile ammonia.

### **3. Experimental conditions**

#### *3.1. Gels preparation*

The physical gels A and B we used, were elaborated from gelatins. The first one, with basic character and pH between 6.3-9.2, was obtained for partial acid hydrolysis of fish proteins. The blue of timol (TB) was the indicator got into the hydrogel. The second physical gel, with pH between 4.7 and 5.2, was synthesized for partial alkaline hydrolysis of animal collagen. In this case the green of bromocresol (BCG) was the indicator.

The chemical gels prepared for radical copolymerization of N-isopropilacrilamida (NIPA) and acid itacónico (AI) in relation 85/15 (NIPA/AI). The N, N '-metilenbisacrilamida (NMBA or BIS), was the crosslinking agent; HPLC methanol and water, the solvents. The V-50 or dihidrocloruro of 2,2 '-azobis (2-amidino-propano), was the initiator. The polymerization temperature was 40 °C. The hydrogels were cut, washed and then were left to dry up to constant weight. In a second stage, the xerogels (dry hydrogels) were sanded down to obtain a uniform diameter and thickness. To incorporate the indicator (blue of timol TB) into the chemical gels, they were put into dissolution of him up to maximum swelling.

#### *3.3. Preparation of the sandwich systems*

The first one, (I), composed by a physical gel core A with TB as indicator, and physical gel B with BCG indicator covers. The second system, (II), with a core of NIPA/AI's chemical gels synthesized with different percentages of crosslinking agent (1.0, 1.5 and 2.0). In this case the first cover was composed of physical gel A with TB and the second one, consist of physical gel B with BCG.

### **4. Results and discussion**

To follow the ammonia volatilization kinetic, 30 minisystems of I and II were immersed into a dissolution of ammonia nitrogen. Every minute and during half an hour, each and every minisystems were extracted to quantify ammonia. The loss of nitrogen was analyzed by means of the method macroKjeldahl [8]. And to determinate ammonia from nitrogeno we considered the Norm NMX-AA-026-1980. The figure 1 shows the behavior of the system II (1.5 % BIS). It is possible to estimate where the change from ammonium to ammonia happens, similar to which we

can see in the bibliography [9].  $\text{NH}_4^+ \rightleftharpoons \text{NH}_3 + \text{H}^+$

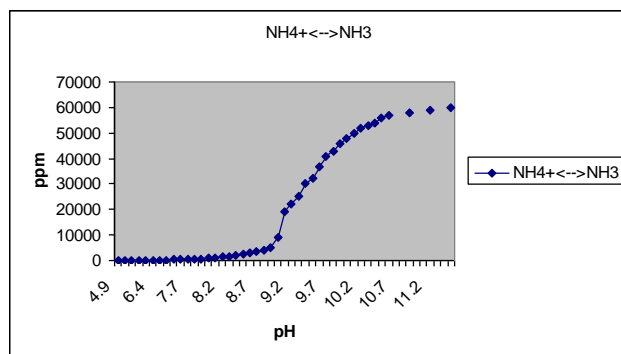


Figure 1. Change from ammonium to ammonia kinetic

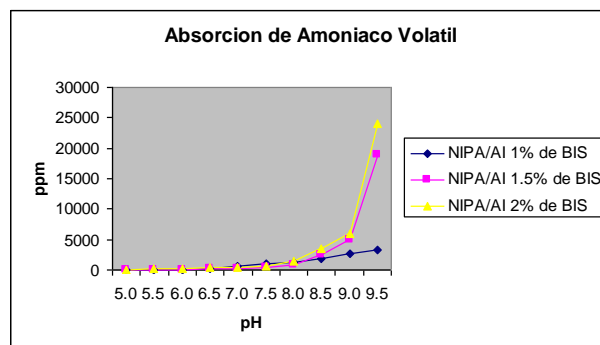


Figure 2. Ammonium absorption kinetic in different conditions: NIPA/AI (85/15) with 1%, 1.5% y 2.0 % of BIS.

After finishing the kinetic, it is possible observed that system II preserves the color in all the points. A week later, only the appearance changed due to the dehydration of the system and the loss of color. On the other hand, the system I composed only by physical gels, was not appropriate to go on the kinetic.

The figure 2 shows the influence of crosslinking agent percentage in ammonia absorption in hydrogels of NIPA / AI (85/15 %). As it is possible to see, the ammonia content is higher in the system of NIPA/AI with 2 % of BIS. When the crosslinking agent quantity in the synthesis of the hydrogel rises, the crosslinking density in the network also increases. As consequence, the distance between network points is lower and produces two effects: on the one hand, an increase of elongation resistance, and on the other hand, the decrease of pore size. The first effect goes to a reduction of liquid that hydrogel can retain, whereas the second one, concerns the speed with which the liquid go into the polymeric network. Apart from that, volatile ammonia absorption is easier because gas molecules remain retained in the small hollows of the network. Both covers that system II presents, are the barrier avoiding that ammonia retained, go out again.

The behavior of these systems in situ was analyzed (Interdisciplinary Center of Research for Integral Development of the Technical National Institute (CIIDIR-IPN) of Jiquilpan, Michoacán). The extraction of all the systems incorporated previously, was realized in a controlled way in certain times, and then, was measured the ammonia quantity retained in them. The results were compared with the laboratory ones with ammonia dissolutions. Figure 3 shows this behavior. It is possible to verify, that volatile ammonia quantity absorbed by the natural way, is lower than quantity that these sandwich systems retained in laboratory conditions. We can

estimate the inverse relation between crosslinking agent percentage and the quantity of ammonia absorbed. This behavior is opposite to the one that takes place in water swelling kinetics of chemical gels used as core of these sandwich systems [10].

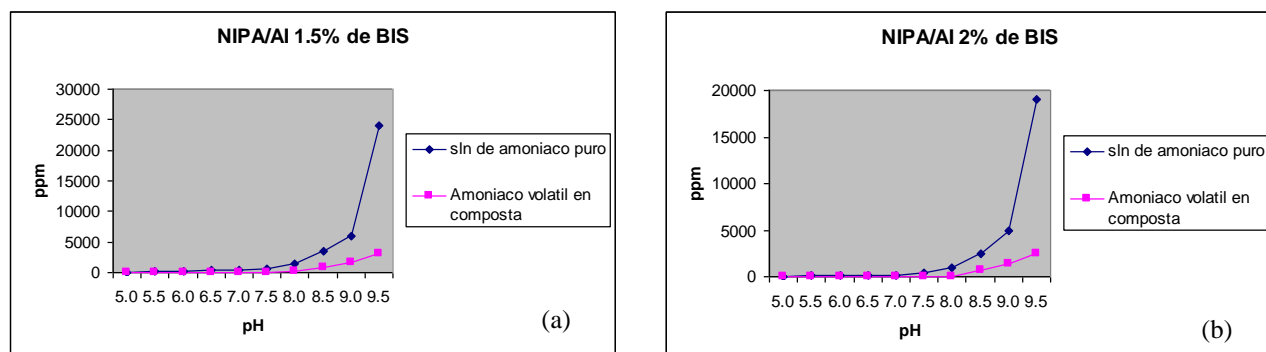


Figure 3. Ammonia absorption kinetic in the sandwich system II with NIPA/AI and different crosslinking agent percentage: (a) 1.5 % of, (b) 2 %, in different means.

## 5. Conclusions

Using physical gels, only is possible to explain the behavior of system, by means of diffusion mechanisms of volatile ammonia in the surface. Whereas in the sandwich system with NIPA/AI's core, also appears, a mechanism of absorption. Physical gel B together with the green of bromocresol indicator turns out to be suitable to detect ammonium ion in volatilization process. According to this, physical gel A with blue of timol (TB), can be considered to detect ammonia. Both gels, A and B, they work like inhibitors of dampness because they act as filter and they only allowed the step to ammonia molecules. It is possible to study and quantify the volatilization process resorting to these systems type sandwich. They are suitable to absorb and quantify ammonia in composts and to know the maturity of the same one.

## 6. References

- [1] Okay, O., Macroporous copolymer networks, *Progress in Polymer Science*, **25**, 711-779 (2000)
- [2] Barón, A., Superabsorbent hydrogel for agricultural applications, *Synthesis and Evaluation*, 7th World Congress of Chemical Engineering, (2005)
- [3] Raju M., Raju P., Síntesis of novel superabsorbing copolymers for agricultural and horticultural applications, *Polymer International*, **50**, 946-951 (2001)
- [4] Sayil, C., Okay, O., Macroporous poly(Nisopropyl) acrilamide networks: formation conditions., *Polymer*, **42**, 7639-7652 (2001)

- 
- [5] Rojas de Gascue B., Ramírez M., Aguilera R., Prin J., Torres C., los hidrogeles poliméricos como potenciales Reservorios de agua y su aplicación en la germinación de semillas de tomate en diferentes tipos de suelos, *Revista Iberoamericana de Polímeros*, **7(3)**, 199, (2006)
- [6] Penagos, J., Quintero, D., (1999), Síntesis de un hidrogel base acrílica para la liberación controlada de sustancias nutritivas agrícolas., Tesis de grado, Universidad Nacional de Colombia (1999)
- [7] Chen, Y., Inbar, Y., Chemical and spectroscopical analyses of organic matter transformations during composting in relation to compost maturity. In: *Science and Engineering of composting: Design. Environmental, microbiological and utilization aspects*. Ed: H.A. Hoitink and H. Keener. The Ohio State University (1993)
- [8] AOAC1984: Official Method of Analysis. 14a. Ed., Association of Official Method of Analytical Chemists, Washington D. C.
- [9] Petrucci R.H., Harwood W. S., Herring F. G., *Química General*. Pearson Educación S.A. España (2002)
- [10] Cornejo J., “Hidrogeles termosensibles para liberación de inmunosupresores”, Tesis de Licenciatura, CUCEI, Universidad de Guadalajara, Jalisco, México (2006)