Furanic polymers. Update and perspectives

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ABSTRACT

Research and developing studies on furanic resins and its applications were necessary do for many years to know their possibilities of use in the industry maintenance activity. An extensive study was done by specialists of the Cuban Research Institute of Sugar Cane Derivatives (ICIDCA) on the development of furanic polymers, third generation derivatives obtained from sugar cane, and their applications as anticorrosive coating, polymeric cement, cold welding compounds, solutions for wood protection, in the sugar and other industries maintenance activities. As results, an investment of a commercial plant of 345 t / year of furanic products was approved after a feasibility study. The Plant will be operated by ZETI-Cienfuegos, located in the province of Cienfuegos in the center-south of Cuba, with ICIDCA´s license of use of the technology. The commercial production of these furanic polymers and its economic impact in the Cuban sugar cane agro industry initially, is another step into the sugar cane diversification.
KEYWORDS: furanic polymers, production, applications, investment, transfer of technology.

RESUMEN

Muchos años de investigación y desarrollo sobre las resinas furánicas y sus aplicaciones fueron necesarios para reconocer sus posibilidades de uso en la actividad de mantenimiento industrial. Especialistas del Instituto Cubano de Investigaciones de los Derivados de la Caña de Azúcar (Icidca) han realizado un extenso trabajo en el desarrollo de polímeros furánicos, tercera generación de derivados de la caña de azúcar, y sus aplicaciones como recubrimientos anticorrosivos, cementos poliméricos, soldaduras metálicas en frío, soluciones para la protección de maderas en la actividad de mantenimiento de la industria azucarera y de otras. Como resultado fue aprobada, después del estudio de factibilidad, una inversión para una planta comercial de 345 t/año de productos furánicos, La planta será operada por Zeti Cienfuegos con licencia de uso de la tecnología del Icidca, la planta está localizada en la provincia de Cienfuegos, centro sur del país. La producción comercial de estos polímeros furánicos y su impacto económico en la agroindustria azucarera inicialmente es de hecho otro paso en la diversificación de la caña de azúcar.
PALABRAS CLAVE: polímeros furánicos, producción, perspectivas, aplicaciones, inversion, transferencia de tecnología.

INTRODUCTION

ICIDCA's researchers, Gómez, *et al.* (1-6) have developed in the last 25 years products based on furan resins, to be used in the protection and maintenance of industrial floors, terraces, passable covers, surfaces of metal, concrete and wood, among other applications. The effectiveness of these products can be verified by works done at installations and constructions belonging to several sectors of the Cuban national economy, in addition to scientific recognitions, patents, and rewards from national Forum of Science and Technique, and in Commercial National Fairs.

The furan resins, produced from furfural and furfuryl alcohol are used in putties and plastic concretes, adhesives, paints and anticorrosive coatings, cold metallic solders, especial coatings and to impregnate (preserve) wood, and they are registered under FURAL trade mark. The aforementioned products substitute similar products based on epoxy, polyester and phenolic resins, which are produced from nonrenewable sources like those from the petro-chemical industries, Diez and Gómez (7), Dopico, *et al.* (8), Diez, *et al.* (9). The objective of this work is to share experiences on furanic polymers development, their productions and uses and on the implementation of the obtained results. An investment of a plant of 345 t /year capacity is being carried out at Cienfuegos's province, in the southern center of the country, destined to the production of furanic polymers, Pérez, *et al.* (10), Cordovés, *et al.* (11).

MATERIALS AND METHODS

The products developed on the basis of furan resins and the implemented services for their applications satisfy the Quality Management Systems on Norm ISO: 9001: 2008.

The FAM and FL resins, from furfural and furfuryl alcohol respectively, are the base resins. They are thermosetting resins with high thermal and chemical stability; their properties are in the Table 1.

In order to satisfy the needs of furanic polymers in the recondition of floors and/or recuperation of pieces during the stages of preventive and corrective maintenance in the Cuban sugar industry an investment of a plant of 345 tons per year, at Cienfuegos's province, in the southern center of the country, is being carried out.

Furanic polymers synthesis doesn't need special or sophisticated installations; it is a versatile unit with minimum technological complexity. The process does not require high temperatures and the reactions occur at atmospheric pressure. The installation has 3 levels in which equipment such as: reactor, condenser, tanks, among others, are placed as it can be seen in Figure 1.

The furanic derivatives that will be commercially produced are: Resin FAM, Resin FL, FURAL Ri1001, FURAL Rr Mortar, FASOL, FURANICID VII and the Resin PB20

Table 1. Resins FAM and FL properties

Properties \ Resin	FAM	FL
Viscosity cPs	2000 – 3000	5000 – 10 000
Density g/cm^3	1,16 - 1,17	1,21 – 1,23
Dry weight %	70 – 75	75 – 85
Gel point (seconds) [a]	5 – 12	5 – 15
Life time (minutes) [b]	40 – 50	-

a: 170 ºC with 12 % of bencensulfonic acid (BSA)
b: At room temperature with 15 % of polietilenpoliamine (PEPA)

RESULTS

The properties of furanic derivatives are presented in Table 2.

Anticorrosive systems (coatings and mortars) for applying on surfaces, and to glue antacid brick.

FURAL-Ri 1001 is used as conditioner layer for the elaboration of anticorrosive mortars, for placement and sealing of antacid bricks, coating of channels, floors and walls; the resin FURAL-Rr mortar is used as finish layer, and to glue antacid bricks, too. In the sugar industry, these products are applied on sugar bulk storage floors, for covering water

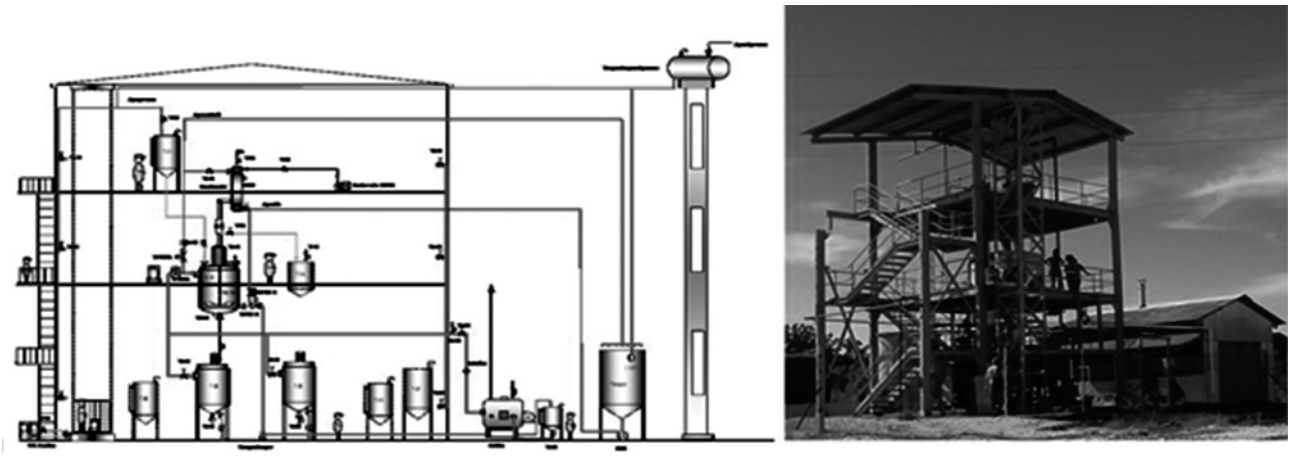

Figura 1. Plant of Furanic polymers.

Table 2. Properties of furanic derivatives

Property	FURAL-Ri 1001	FURAL-Rr Mortar	FASOL	FURANICID VII	PB20
Volume Mixing Relation (resin/hardener)	4:1	4:1	-	-	-
Application temperature (ºC)	15 - 40	15 - 40	-	-	-
Strengthening time (h)	24	24	-	-	-
Useful application time (min)	25 – 50	25 – 50	-	-	-
Storage time at room temperature (years)	2	2	-	-	-
Maximum temperature to resist (ºC)	150	150	-	-	-
Minimum temperature to resist (ºC)	- 20	- 30			
Density (g/cm ^{3})	1,11 – 1,13	-	1,12 – 1,29	1,24 – 1,26	1,24 – 1,26
Viscosity (cP)	100 - 200	-	50 – 150	280 – 480	50 – 80
Adherence (MPa)	45 - 50	45 - 50	-	-	-
Performance kg/m ^{2}x 1 mm thickness	0,6 – 0,8	2,0 – 3,5	-	-	-
Dry weight (%)	50 - 60	-	50 - 60	65 - 75	55 - 60

Table 3. Properties of furanic covering

Property	Concrete	Mortar	Putties	Cement
Density g/cm ^{3}	2.1-2.4	1.8-2.0	1.6-2.0	1.8-2.0
Compression R. MPa	50-70	70-80	100-120	60-80
Traction R. MPa	4-5	6-7	10-12	6-7
Flexion R. MPa	12-14	20-30	30-35	18-20
Thermal R. ºC (Martens)	250-300	250-300	250-300	250-300

Figura 2. Coatings for the protection of floors, terraces, passable and not passable covers and concrete deposits in general.

treatment area, to covering floors of sugar production, storage tank of molasses, channels of effluents. The properties of these polymeric compounds are in Table 3 and an example of application in the figure 2.

Wood Impregnation with furanic product.

The furanic product to impregnate and protect the wood will be useful in various applications (Figure 3). It has the advantage of giving good resistance to the wood against biological and environmental agents, and increases the mechanical resistance, too; this product brings dimensional stability to the treated wood, which becomes resistant to the water. The product can be applied with brushes; by submerging the wood in it or by introducing the wood into an autoclave; the selected method will depend on the grade of desired protection and final application of the wood treated. The obtained final product is a dark-color wood, of high density and good physical mechanical property .

Figura 3. Impregnation of wood with furanic product.

Table 4 Properties of Metallic cold welding

Metallic cold welding	Properties				
	Traction Resistance (MPa)	Flexion Resistance (MPa)	Compression Resistance (MPa)	Shearing strength (MPa)	Thermic stability (ºC)
Aluminum	27	22	26	13	= 200
High Tenacity	32	45	38	13	= 200
Iron	17	41	38	10	= 200
Bronze	7	19	34	12	= 200

Furanic polymeric compounds for the reconditioning of pieces

The properties of the structural adhesive formulated as cold metallic solder "FURAL" are in Table 4 and examples of applications in Figures 4, 5, 6 and 7.

Recovering of cane milling machinery (virgin and bench) with cold metallic solder

The principal stages of the process of recovering of this equipment with the cold metallic solder can be seen in the figures 3 to 5.

The uses of furanic polymers products are:

- FURAL Ri1001: It is the conditioner and barrier for chemical resistance of surfaces and concrete deposits and wood; after it, another FURAL product is applied.

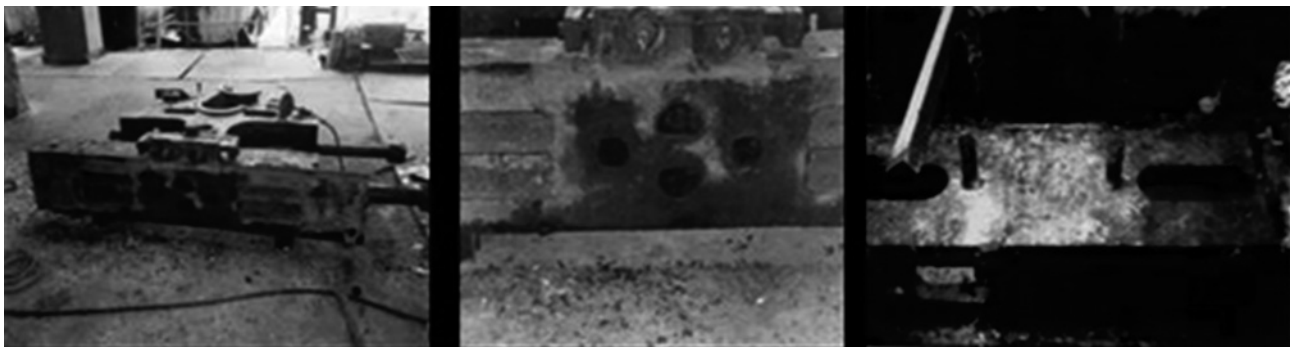

Figura 4. Components of cane milling machinery (virgin and bench) before recuperation.

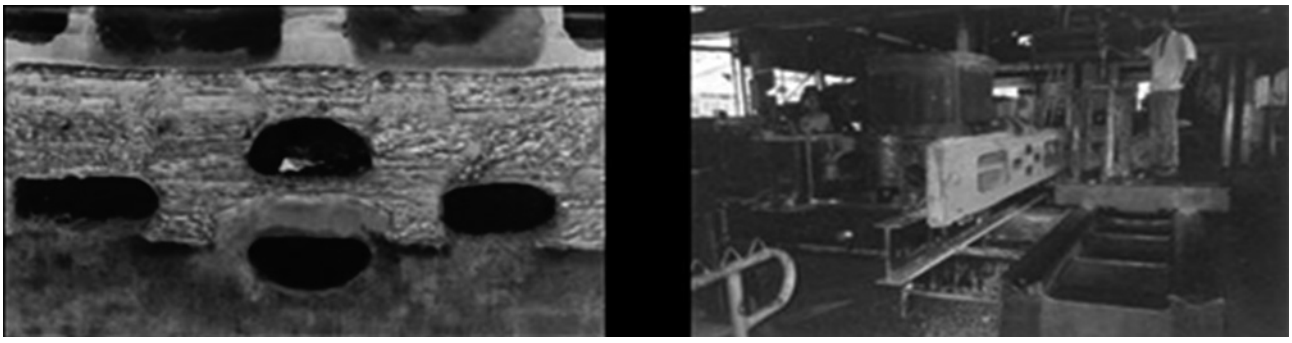

Figura 5. Views of cane milling machinery (virgin and bench) using traditional method of recuperation: electrode welding and machine tool.

Figura 6. Views of cane milling machinery (virgin and bench) using cold metallic welding recuperation method.

Figura 7. Other cold welding application.

- FURAL Rr (Mortar): It is applied in the sealing of metallic and concrete deposits, technological floors of different industries, plants of water treatment, filters and reactors of ionic interchange, on laboratory tables, floors of kitchens, etc.
- FL resin: It is used in the manufacture of goods of reinforced plastics with fiberglass (FGRP) for tanks and pipes; in the manufacture of antacid cements of high thermic stability, in the elaboration of oxide converter and in especial coatings against rust.
- FURANICID VII resin: It is recommended for foundry processes "not bake" and "hot box". It enables a males' fast hardening, offering good resistance to the penetration of the liquid metal.
- PB 20 resin: It is used to increase the adhesiveness of lime paints. It has been utilized also as agglutinant of sands in foundry process.
- FASOL: product for the protective treatment of wood. Protects against the attack of fungi, insects and against the humidity. Increases the mechanical resistance of the treated wood, and protects the wood against the chemical common solvents (according to the method of used treatment).

The production and applications of these products in the Cuban sugar sector (Group AZCUBA), guarantees:

- Cold metallic solder and especial coatings.
- Anti corrosive paints.
- Converter of oxides.
- Product for wooden protection.
- Resins for foundry process (Ferrous and no ferrous).
- The production of an improved lime-paint.

CONCLUSIONS

- New materials from furanic polymer products have been developed; they can be defined as

the third generation by-products from sugar cane.
- These furanic polymers have been evaluated in applications related with the maintenance works in the sugar industry and other industries.
- The principal uses of furanic polymers are in anticorrosive coatings, mortars and polymeric cements, metallic cold solder, protection of wood and other.
- The attained results have promoted the investment of a plant for the production of 345 tons/year of furanic polymers at Cienfuegos's province.
- The destination and impact of these products will be in the activity of maintenance of the sugar industry, fundamentally in those where an important weight has the recuperation of pieces and the anticorrosive protection.

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