AJELIS
ADJUSTABLE RECYCLING SYSTEMS

METALICAPT®-NFB11

TECHNICAL DATA SHEET

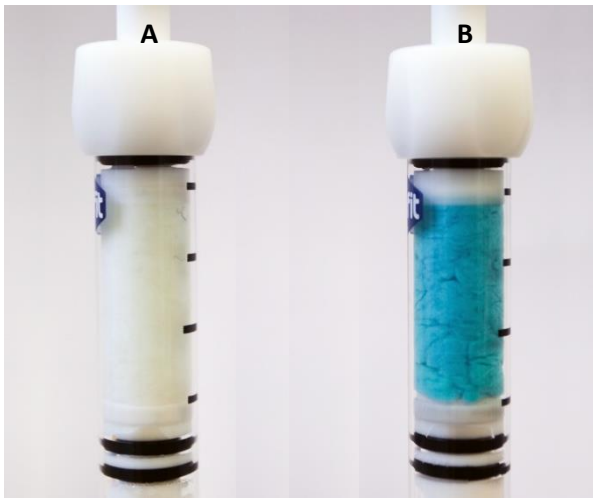
VERSION 7

AJELIS - 86 rue de Paris - 91400 Orsay - France
Phone +33(0)6 08031680 - www.ajelis.com - email : contact@ajelis.com
Social capital10 000 EUR - SIREN 804 731 578 - intra-community VAT FR 61 804 731 578

TECHNICAL DATA SHEET - METALICAPT®-NFB11

• PRESENTATION

METALICAPT®-NFB11 *is a new material composed of polymer fibers. It has a strong cation complexation ability. Physical and chemical properties of* ***METALICAPT®-NFB11*** *allowed an improvement of the capacity and the flow rate compare to ion exchange resins, currently market leader.* ***METALICAPT®-NFB11*** *is also enable to treat large volumes of effluents in a minimum time with the possibility of a regeneration of the material.*



A. METALICAPT®-NFB11 prepared for the treatment of contaminated effluents; **B. METALICAPT®-NFB11** after treatment of a solution charged with Copper (II) ions.

Main fields of application:

- *Lowering the heavy metal concentration from aqueous solutions: Copper (II), Nickel (II), Zinc (II), Cadmium (II), Cobalt (II), Strontium (II), Lead (II), Magnesium (II), Chromium (III), Iron (II);*
- *Water treatment: removing of Calcium and Magnesium ions;*
- *For some metals: lowering the concentration beyond current regulations;*
- *Reduction of the effluent volume thanks to a concentration of heavy metal contaminated aqueous solutions.*

• MATERIAL PROPERTIES

Capacity (Q_e) for Copper (II)	$170 \leq Q_e \leq 210$ mg Cu (II)/g
Threshold level for Copper (II)	< 0.05 mg/L
Density of dry material	0.15 g/mL
Density of conditioned material	1.15 g/mL
Flow rate	from 50 $L.min^{-1}.m^{-2}$

Material performances were demonstrated with a specific protocol and in adapted conditions. A personalized study may be offered by the ***AJELIS*** *Company in order to meet the needs of our customers and delivered the best solution for their effluent decontamination problematic.*

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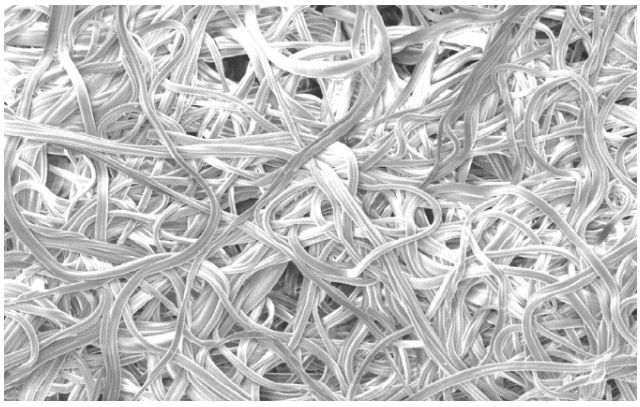
• MATERIAL DESCRIPTION

METALICAPT®-NFB11 is a polymeric adsorbent with a fiber structure insoluble in aqueous solutions. Its chemical composition is similar to weakly acidic cation exchange resin. The material is delivered dry in a sodium form. **METALICAPT®-NFB11** presents a fiber structure close to the cotton structure. These fibers, with a diameter of about one micron, can be observed by electronic microscopy.

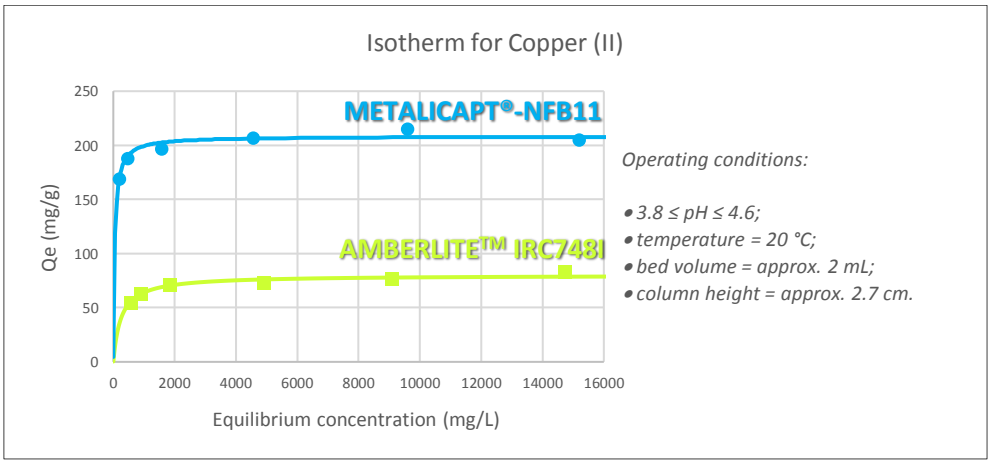


METALICAPT®-NFB11 picture obtained by electronic microscopy after treatment by a Copper (II) solution.

• TECHNICAL DATA

Adsorption isotherm for a solution charged with Copper (II) ions

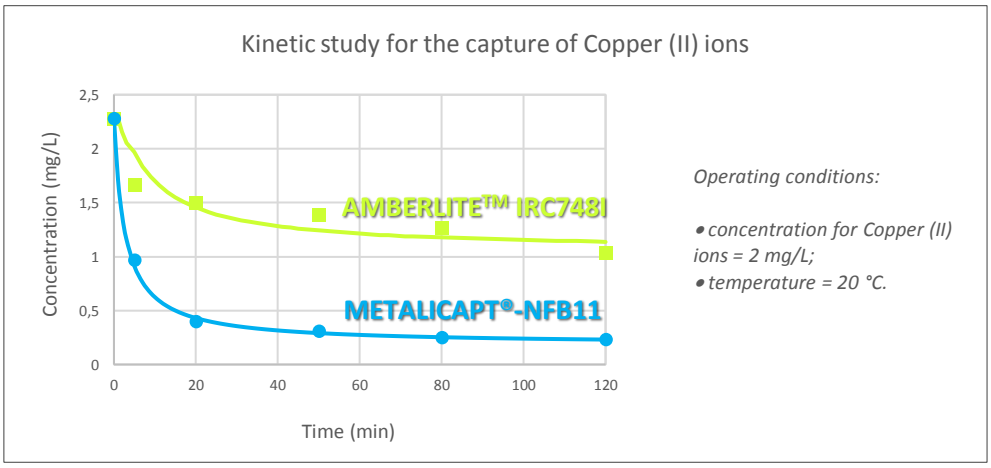
To determine properties of the material, an adsorption isotherm was realized for Copper (II) ions. The maximum capacity (Q_{max}) was measured at 208 mg of Copper (II)/g of **METALICAPT®-NFB11** material. Under the same operating conditions, the AMBERLITE™ IRC748I material (a weakly acidic cation resin), specific for the capture of metals, showed a Q_{max} of 79 mg of Copper (II)/g of ion exchange resin. **METALICAPT®-NFB11** offers the highest performances in terms of capture.



Another study showed that the presence of a background salt (NaCl at 0.1 mol/L) did not modify adsorption properties of the material.

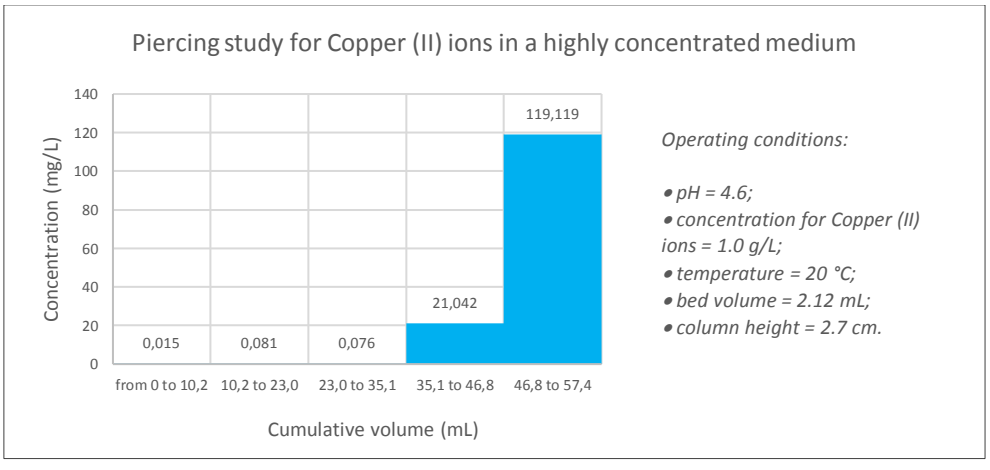
Kinetic study for the capture of Copper (II) ions

A kinetic study was operated to compare the efficiency of the **METALICAPT®-NFB11** material versus the ion exchange resin AMBERLITE™ IRC748I. These results show that the **METALICAPT®-NFB11** material achieves a thermodynamic equilibrium with Copper (II) ions faster than the AMBERLITE™ IRC748I resin. Moreover it still has a higher capacity and a better threshold level.



Piercing study for Copper (II) ions

METALICAPT®-NFB11 is an adapted material for the elimination of heavy metals from residual water. Thank to piercing studies with Copper (II) ions in highly concentrated (1 g/L) and weakly concentrated (2 mg/L) media, it has been shown that the **METALICAPT®-NFB11** material is in agreement with current regulation in terms of effluents[1] with values well below 0,1 mg/L before piercing. Current regulation recommends limit values between 0.5 to 2 mg/L for Copper (II) ions.



[1] Limit values: Copper and its derivatives 0.5 mg/L if the effluent does not exceed 5 g/day; concerning the production and transformation of Copper, the limit value is 1 mg/L; source INERIS, 2014. Données technico-économiques sur les substances chimiques en France : Cuivre, composés et alliages, DRC-14-136881-02236A, 91 p. (http://rsde.ineris.fr/ ou http://www.ineris.fr/substances/fr/)
Quality of drinking water: Copper: the quality limit is fixed at 2 mg/L and the quality reference is fixed at 1 mg/L; source Circulaire DGS/SD 7 A n° 2004-45 du 5 février 2004 relative au contrôle des paramètres Plomb, Cuivre et Nickel dans les eaux destinées à la consommation humaine

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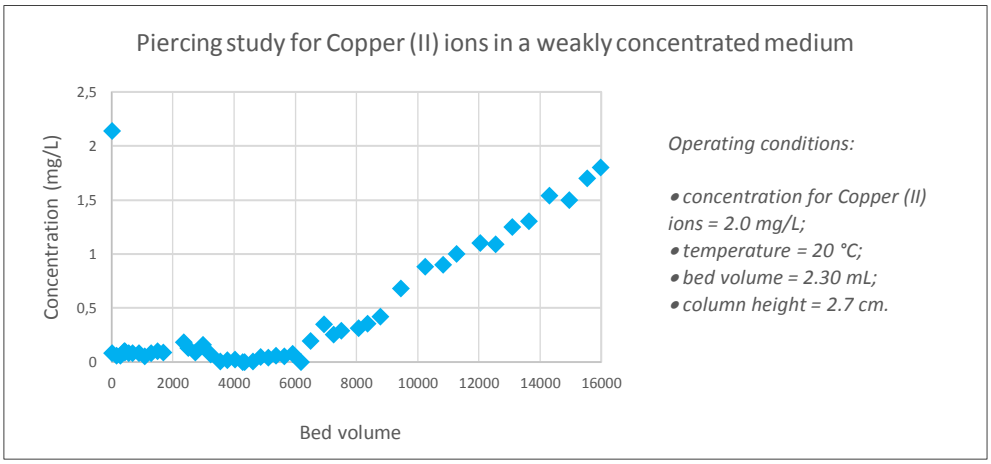


Capacity in the presence of interfering agents

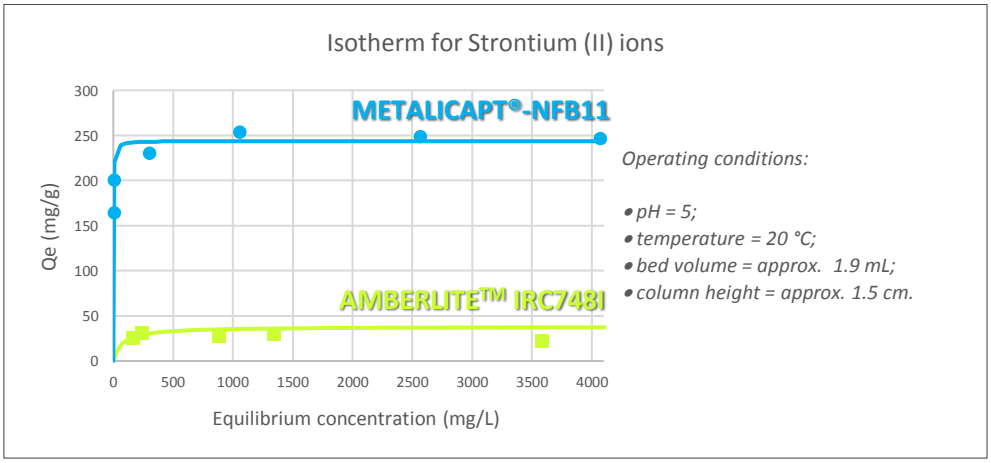
Depending of the nature of the effluent, different agents can interfere with the Copper (II) ions adsorption step on the **METALICPAT®-NFB11** material. Some amounts of Sodium (I) ions (Na^+) and Calcium (II) ions (Ca^{2+}) were tested in order to determine the new capacity (Q_e).

Metallic ion	*Interfering agent*	*Ratio*	*Capacity Q_e (mg/g)*
Cu^{2+}	-	-	169
Cu^{2+}	Na^+	Cu^{2+}/Na^+ 1:10	169
Cu^{2+}	Na^+	Cu^{2+}/Na^+ 1:500	146
Cu^{2+}	Ca^{2+}	Cu^{2+}/Ca^{2+} 1:1	158
Cu^{2+}	Ca^{2+}	Cu^{2+}/Ca^{2+} 1:100	70

Operating conditions: initial concentration for Copper (II) ions = 0.7 g/L; temperature = 20 °C; bed volume = approx. 2 mL; column height = 2.7 cm.

Adsorption isotherm for a solution charged with Strontium (II) ions

Strontium (II) ions can also be captured by the **METALICAPT®-NFB11** material. From the obtained adsorption isotherm the maximum capacity (Q_{max}) has been determine to be 244 mg of Strontium (II)/g of **METALICAPT®-NFB11** material.



Under the same operating conditions the AMBERLITE™ IRC748I ion exchange resin, an industrial chelating resin for the capture of metals shows a Q_{max} of 38 mg of Strontium (II)/g of resin.

Capacity for different metallic ions

In order to reveal the adaptability of the **METALICAPT®-NFB11** material, the capacity (Q_e) for several metallic ions was determine with the below selectivity (depending on concentration, pH, interfering agents, etc.):

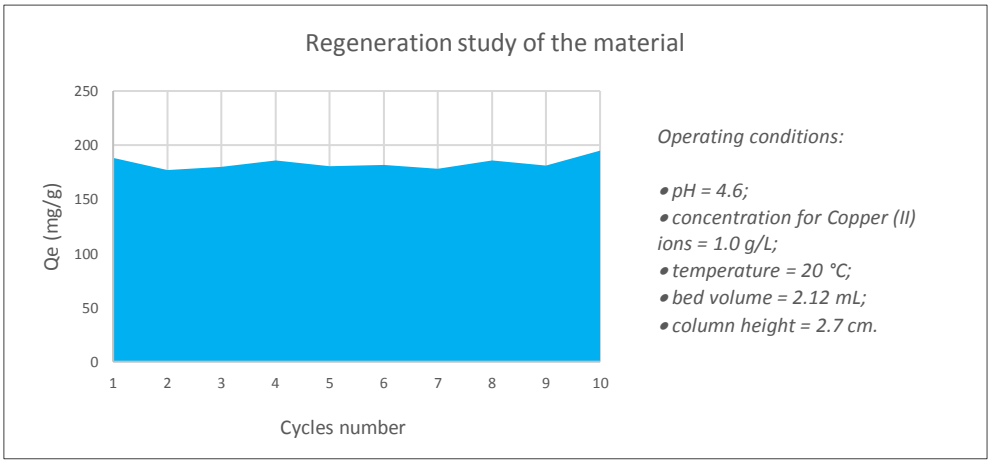
$$Ca^{2+} < Cr^{3+} < Eu^{3+} < Fe^{2+} < Zn^{2+} < Ni^{2+} < Co^{2+} < Cd^{2+} < Cu^{2+} < Pb^{2+} < Mg^{2+} < Sr^{2+}$$

Metallic ions	*pH*	*Capacity Q_e (mg/g)*	*Capacity Q_e (méq/g)*
Ca^{2+}	5,0	80	4,0
Cd^{2+}	5,0	186	3,3
Co^{2+}	5,0	183	6,2
Cr^{3+}	4,0	83	4,8
Cu^{2+}	5,0	188	5,9
Eu^{3+} *	-	105	2,1
Fe^{2+}	4,0	121	4,3
Mg^{2+}	5,5	215	17,7
Ni^{2+}	5,0	147	5,0
Pb^{2+}	4,0	195	1,9
Sr^{2+}	5,0	254	5,8
Zn^{2+}	5,0	124	3,8

*Operating conditions: initial concentration for metallic ions = approx. 1 g/L (*for Eu^{3+} = 20 g/L); temperature = 20 °C; bed volume = approx. 2 mL; column height = 2.7 cm.*

Regeneration method of the material

2 to 4 bed volumes of a 3.1% hydrochloric acid solution (corresponding to 1 mol/L) are needed for the regeneration of the **METALICAPT®-NFB11** fibers (90-100%). Several saturation/regeneration cycles were performed to show the continued performances of the material.



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• CONCRETE EXAMPLE: RECOVERING OF CONTAMINANT METAL IONS IN RESIDUAL WATER FROM THE SURFACE TREATMENT INDUSTRY

With the cooperation of the Company BERTIN-AUBERT, an actor in the surface treatment industry, **AJELIS** carried out a study for the treatment of real effluents produced by the process of electrotyping. When they are removed from the production process, different heavy metal containing baths (Copper, Nickel, Zinc…) are treated by an external company specialized in the recycling of chemical wastes (by collection or directly on the site with ion exchange resins).

Treatment of a solution charged with Copper (II) ions

5 liters of a Copper (II) solution with a concentration of 754 mg/L (pH 2) from a rinsing bath was collected. This effluent was treated by a 620 mL column packed with the **METALICAPT®-NFB11** material (two passages are needed). After treatment the water shows a concentration for Copper (II) ions less than 0.6 mg/L which is below limits stated by the current regulation for the concentration of Copper (II) ions containing in rejected water.[1]

Treatment of a solution charged with Nickel (II) ions

A Nickel (II) sulfamate solution has been treated by the **METALICAPT®-NFB11** material. This rinsing bath presents a concentration for Nickel (II) ions of 2.91 g/L (pH 3). The effluent was treated by a 620 mL column packed with the **METALICAPT®-NFB11** material. After four passages on this system, the concentration for Nickel (II) ions reached 6.0 mg/L. These values are closed to the current regulation concerning limits about Nickel emissions.[2] Solutions concerning the implementation of the material are currently experimented to obtain concentrations of Nickel below limits stated by the regulation.

Treatment of an alkaline solution charged with Copper cyanides

In a first step, this rinsing bath was treated by a NaClO solution (bleach) in order to oxidize cyanide ions into cyanate ions, much less toxic. The resulting solution shows a concentration for Copper (II) ions of 0.13 mg/L (pH 10). This value is below current limits in terms of Copper (II) ions emission in water. The treatment of this solution by the **METALICAPT®-NFB11** is not required.

Treatment of a solution charged with Lead (II) and Tin (II) ions

This rinsing bath is composed by Lead (II) ions at 283 mg/L and Tin (II) ions at 6.07 g/L (pH 1). In a first step, the solution was treated with a NaOH solution to reach a pH value of 10 (precipitation). After a decantation step, concentrations for Lead (II) and Tin (II) ions are respectively about < 0,1 mg/L et 809 mg/L. For Lead (II) the concentration is below regulations.[3] One passage of the decanted and filtered solution on the **METALICAPT®-NFB11** material shows a limited

[2] According to French regulations concerning drinkable water quality (Decree n° 89-3 from January the 3st 1989 modified, annex I.1), industrial wastewater are limited to 0.5 mg/L if the flow is up to 5 g of Nickel per day. A less restrictive limitation has been developed for production and transformation of Nickel: 2 mg/L. Otherwise surface treatment sector fall under the decree from September the 26th 1985, published at JO from November the 16th 1985); Drinkable water quality: the decree 2001/1220 from December 20th 2001 and the corresponding European regulation demand a limit for the quality of drinkable water intended for human consumption. This water should respect a limit value less than or equal to 20 µg/L for Nickel; source INERIS, 2006. Données technico-économiques sur les substances chimiques en France : Nickel et ses principaux composés, DRC-14-136881-02234A, 94 p. (http://www.ineris.fr/rsde/ ou http://www.ineris.fr/substances/fr/)
Limits for concentration are defined as follow in mg/L (milligram per liter of rejected effluent), checked on untreated and non-decanted effluent […] Nickel 5.0 mg/L; source Arrêté du 26/09/85 relatif aux ateliers de traitement de surface paru au JO du 16 novembre 1985 (http://www.ineris.fr/aida/consultation_document/5985)

[3] For installations subject to ICPE authorization. Heavy metals. Lead: 0.5 mg/L if the reject is below 5 g/day. Decree from February the 2st 1998 modified related to samples and water consumption as well as emissions from installations subject to authorization for the protection of the environment, named "integrated

effect on the concentration for Tin (II) ions which passed from 809 to 747 mg/L. An adapt process with several passages is under study.

Treatment of a cyanide solution charged with traces of Copper (II), Zinc (II), Gold (II), Lead (II) and Tin (II) ions

This rinsing bath is composed by Copper (II) ions at 112 mg/L, Zinc (II) ions at 5.6 mg/L, Gold (II) ions at 53 mg/L, Lead (II) ions at 2.5 mg/L and Tin (II) ions at 3.9 mg/L (pH 8). In a first step, this rinsing bath was treated by a NaClO solution (bleach) in order to oxidize cyanide ions into cyanate ions, much less toxic. The resulting solution shows a concentration for Copper (II) ions of 0.12 mg/L, for Zinc (II) ions of 0.43 mg/L, for Gold (II) ions of 48 mg/L, for Lead (II) ions of < 0.1 mg/L and for Tin (II) ions of 1.14 mg/L. On one hand, toxic metals Copper, Zinc, Lead and Tin show concentrations below current regulations. On the other hand, a post-treatment by the **METALICAPT®-NFB11** not allowed to decrease significantly the concentration for Gold (II) ions (from 48 to 46 mg/L) because these ones are interfered by cyanide ions. A specific material for cyanide complexes needs to be employed in order to solve the treatment of this type of toxic agents (development in progress at **AJELIS**).

decree"; source CCI Paris-Île-de-France, Rejets d'eaux - Mécanique et travail des métaux (http://www.entreprises.cci-paris-idf.fr/web/environnement/eau/gerer-eau-metier/rejets-eaux-mecanique)

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