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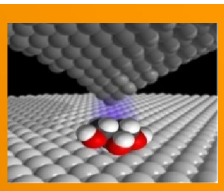

ELECTROCHEMICAL POLISHING OF ALUMINUM IN CHOLINE CHLORIDE BASED IONIC LIQUIDS

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Motivation

Electrochemical polishing represents a clean way to obtain micro-smooth, contaminant free metallic surfaces without producing any thermal or physical distortion. The standard processes for Al electropolishing involve the use of electrolytes containing mixtures of strong inorganic acids, sometimes working at relatively high temperatures. In the last years, a green chemistry based on ionic liquids gained a wide recognition as potentially benign solvents and widespread application.
Recently it has been shown the possibility of formation of ionic liquids from eutectic mixtures of quaternary ammonium salt such as choline chloride (2-hydroxy-ethyl-trimethyl ammonium chloride) with a hydrogen bond donor species such as amides, glycols or carboxylic acids. These media, also known as "deep eutectic solvents (DES)" are characterized by good air and water stability. They are potentially recyclable, biodegradable and with no harm on human health.
Thus, the present paper presents some preliminary experimental results regarding the electrochemical polishing of aluminum in choline chloride based ionic liquids. .

Experimental details

- ***Electropolishing experiments have been performed in a two-electrode cell, using a direct current power supply (0-5A, 0-60 V);***
- ***Al electrodes (Al foil #0.2 mm; Al strip #0.5 mm; Al rod ϕ 5.5 mm) of 99.5 purity have been used, against a stainless steel counterelectrode;***
- ***Operating temperatures in the range of: 5-85°C, for different periods between 1-30 min.;***
- ***Linear polarization curves at 20 mV/s have been recorded involving an AUTOLAB PGSTAT 12 equipment;***
- ***The electrochemical cell included a WE- Al, an Ag wire as a quasi-reference electrode and a Pt counterelectrode***

Ionic liquid systems used for Al electrochemical polishing

System type	Electrolyte composition
ILEG	ChCl:EG 1:2 molar ratio
ILEG -OxAc	ILEG + 3% oxalic acid
ILEG-$VOSO_4$	ILEG +2% $VOSO_4$
IL	ChCl:urea 1:2 molar ratio
IL-OxAc	IL + 3% oxalic acid
IL-$VOSO_4$	IL + 2% $VOSO_4$

*ChCl-choline chloride; EG-ethylene glycol; OxAc- oxalic acid; VOSO4-vanadyl sulfate

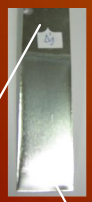
ILEG-OxAc system

ILEG-$VOSO_4$ system

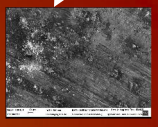
RESULTS AND DISCUSSION

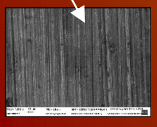
Electropolishing operating parameters and the appearance of the modified Al surface

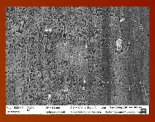
IL type	Al substrate type	Current density, A/dm^2	Temperature, °C	Time, min.	Surface Appearance
ILEG	Al strip	5	7-8	6	Bright
		10	7-8	6	Smoothed, dull
ILEG-OxAc	Al strip	4	14	6	Very bright
		8	27	0.5-1	Dull
	Al foil	3.3	7	5	Bright
		3.3	17	10	Bright
		4	3-12	10	Bright
ILEG-$VOSO_4$	Al strip	4	3-14	10	Bright
	Al foil	3.3	20-30	15	Bright
		15	40-50	7	Surface leveling, nonhomogeneous bright
IL	Al strip	4-6	45-85	5-6	Etched surface
IL-OxAc	Al strip	3-3.5	70-90	5-10	Surface leveling, dull
		2-2.5 (constant voltage)	70	10-20	Bright
IL-$VOSO_4$	Al strip	1-2	25-30	5-10	Dull surface with white spots
		1-2	60-70	5-10	Dull surface with white spots

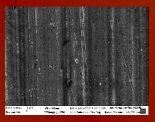


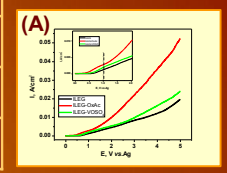
Comparative SEM micrographs of electropolished Al using ILEG-OxAc system at 5 °C, 5 min. 4 A/dm^2 (right) and bare Al (left) surfaces

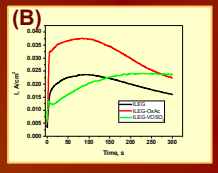




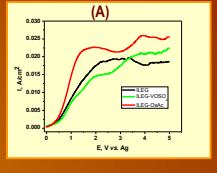


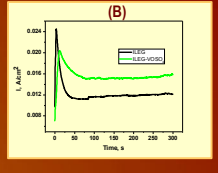






(A) Linear polarization curves for Al foil electrode in different ionic liquid systems, at 20 mV/s; (B) I-t transients at E=+1V/Ag wire ref.





(A) Linear polarization curves for Al rod electrode in different ionic liquid systems, at 20 mV/s; (B) I-t transients at E=+1V/Ag wire ref.

CONCLUSIONS

- ***Choline cloride based ionic liquids may represent a potential environmental friendly viable alternative for aluminum electrochemical polishing;***
- ***The selection of the optimum working parameters is closely related to the Al bare metal characteristics (e.g. purity, composition, metallurgical treatments, heat treatment, etc.);***
- ***Future investigations are scheduled for a deeper understanding of the mechanism in the presence of different additives and a better optimization of the main parameters (e.g. temperature, current density, time) against the involved ionic liquid composition.***

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