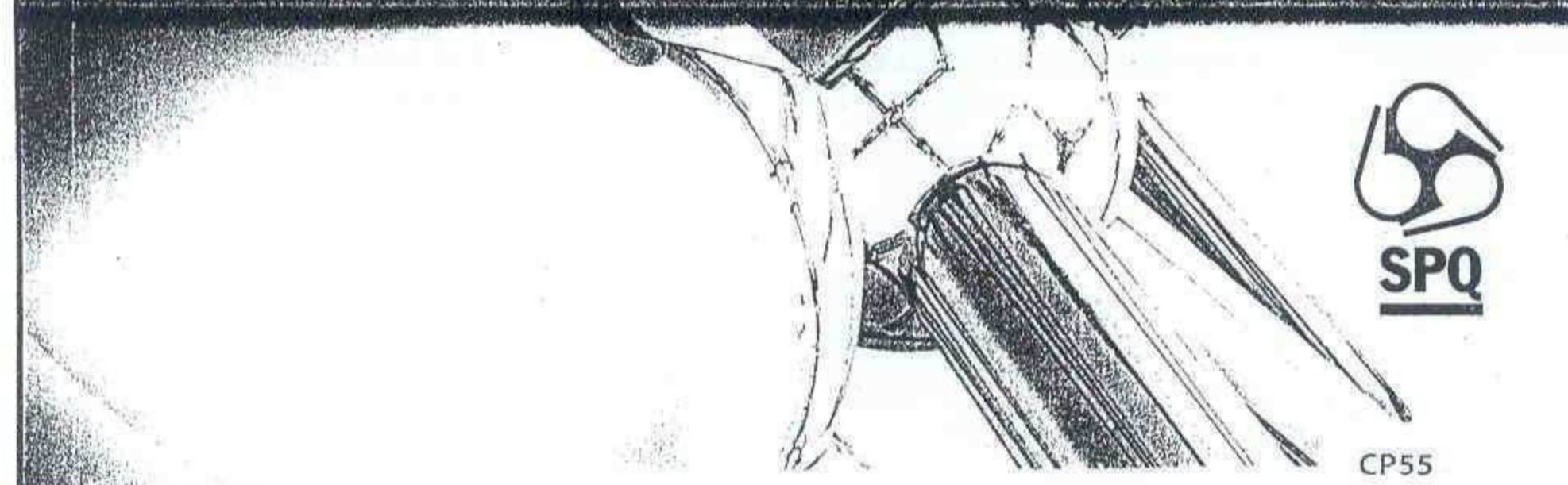


# XXI Encontro Nacional SPQ

## Química e Inovação

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Faculdade de Engenharia da Universidade do Porto



CP55

### CYCLIC VOLTAMMETRIC ANALYSIS OF 2-STYRYLCHROMONES

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2-Styrylchromones (2-SC) are a chemical family of heterocyclic compounds, vinylogues of flavones (2-phenylchromones), whose occurrence in nature has been reported. Recently, several 2-SC derivatives were demonstrated to entail antioxidant properties, namely, xanthine oxidase inhibition, hepatoprotection against pro-oxidant agents in cellular and non cellular systems, and scavenging activity against reactive oxygen and reactive nitrogen species (ROS and RNS).

Cyclic voltammetry is a widely used electroanalytic technique that allows determining the redox properties of molecules in a solution. This technique has previously been used to study the electrochemical oxidation mechanisms of flavonolic compounds. In the present work, the electrochemical behaviour of several 2-SC was studied by cyclic voltammetry, together with a number of flavonoids with well known antioxidant activities, and the results correlated to their ability to scavenge ROS and RNS.

The results obtained showed that 2-SC with a catecholic B-ring have a low oxidation peak corresponding to the oxidation of the 3',4'-OH (catechol) moiety. A detailed analysis of this peak indicated a reversible redox process with a coupled chemical reaction. The compounds with a phenolic B-ring have a common peak, with oxidation potential values of about +0.4/+0.5 V vs. Ag/AgCl, corresponding to the oxidation of the 4'-OH. The oxidation of the hydroxyl substituents in the A-ring generated peaks of higher potentials (+0.7/+0.8 V vs. Ag/AgCl).

The results from the cyclic voltammetry assays were in agreement with those from scavenging activity assays, i.e., lower values of oxidation potentials corresponded to higher scavenging effects. The oxidation potentials obtained by cyclic voltammetry seem to be applicable as a general indicator of radical scavenging activity.

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## INTRODUCTION

2-Styrylchromones (2-SC) are a chemical family of heterocyclic compounds, vinyllogues of flavones (2-phenylchromones), whose occurrence in nature has been reported. Recently, several 2-SC derivatives were demonstrated to entail antioxidant properties, namely, xanthine oxidase inhibition<sup>1</sup>, hepatoprotection against pro-oxidant agents in cellular<sup>2</sup> and non cellular systems<sup>3</sup>, and scavenging activity against reactive oxygen and reactive nitrogen species (ROS and RNS)<sup>4</sup>.

Cyclic voltammetry is a widely used electroanalytical technique that allows determining the redox properties of molecules in a solution. This technique has previously been used to study the electrochemical oxidation mechanisms of flavonolic compounds. In the present work, the electrochemical behaviour of several 2-SC was studied by cyclic voltammetry, together with a number of flavonoids with well known antioxidant activities, and the results correlated to their ability to scavenge ROS and RNS<sup>4</sup>.

## EXPERIMENTAL PROCEDURES

Electrochemical measurements were carried out in an Autolab electrochemical system (Eco Chemie model PGSTAT 10) and data acquisition was accomplished through GPES software (Version 4.6). Voltammetric signals were recorded at room temperature. The working electrode was a glassy carbon electrode (3.0 mm diameter). A Ag/AgCl (KCl 3M) electrode was used as reference and a carbon electrode was used as auxiliar. The glassy carbon working electrode was polished with alumina 0.075  $\mu\text{m}$  aqueous slurry before every experiment. Cyclic voltammograms were obtained by a single cycle performed at a scan rate of 100  $\text{mV s}^{-1}$ . For the scan rate studies, the scan rate was varied from 10 to 200  $\text{mV s}^{-1}$ . Voltammetric scans were carried out in the potential interval of  $-0.2$  to  $+1.0$  V vs. Ag/AgCl.

## STATISTICAL ANALYSIS

Pearson correlation test was performed using GraphPad Prism version 5.00 for Windows, GraphPad Software, San Diego California USA, [www.graphpad.com](http://www.graphpad.com).

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## RESULTS AND DISCUSSION

Cyclic voltammograms of 2-SC from group 1 (1A-1D) showed the permanent presence of a low potential oxidation peak, with a correspondent reduction peak being detected in the reverse scan, and a second oxidation peak at higher potentials.

An oxidation peak with oxidation potential ( $E_{p_{ox}}$ ) values between  $+0.4$  and  $+0.5$  V vs. Ag/AgCl was visible in the cyclic voltammograms of the compounds from group 2 (2A-2D). It was observed a second oxidation peak at higher potentials for the compound 2A. The compounds 3A-3C originated an oxidation peak with  $E_{p_{ox}}$  values comparable to those of the second peak of compounds 1A-1C and 2A. These oxidation peaks appear to correspond to irreversible processes, since no current was observed in the reverse scan. For compound 3D there were no detectable peaks.

The cyclic voltammogram of luteolin presented one oxidation peak and a correspondent reduction peak. The flavones chrysin, 5-OH flavone, and 7-OH flavones revealed a common oxidation peak which appeared at potentials around  $+0.8$  V vs. Ag/AgCl. Apigenin showed two possible oxidation peaks, although barely defined, not allowing the determination of the  $E_{p_{ox}}$  values.

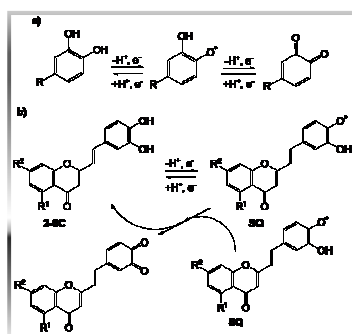


Fig. 2 – a) Mechanism of oxidation of catechol-like compounds; b) Proposed oxidation mechanism of 2-styrylchromones.

Correlations between the  $E_{p_{ox}}$  of the first peak and the scavenging activity against ROS and RNS<sup>4</sup> were analyzed by using the Pearson correlation test.

Significant correlations were found for  $\text{H}_2\text{O}_2$ , hypochlorous acid (HOCl), singlet oxygen ( $^1\text{O}_2$ ), and peroxyntirite, indicating that the scavenging mechanism against these reactive species is based on redox reactions. No significant correlation was found for superoxide radical ( $\text{O}_2^-$ ).

Table 2 – Correlations (Pearson correlation coefficients) between the  $E_{p_{ox}}$  and the scavenging activity against ROS and RNS<sup>4</sup> of the tested 2-SC

	$\text{O}_2^-$	$\text{H}_2\text{O}_2$	HOCl	$^1\text{O}_2$	OHNO <sup>2</sup> without NaHCO <sub>3</sub>	OHNO <sup>2</sup> with NaHCO <sub>3</sub>
$E_{p_{ox}}$	0.0527	0.0182**	0.7807*	0.6815**	0.7308*	0.7341**

<sup>a</sup>IC<sub>50</sub>; <sup>b</sup>% effect at 125  $\mu\text{M}$ ; <sup>c</sup>IC<sub>50</sub>; <sup>d</sup>IC<sub>50</sub>; \*significant at  $p < 0.05$ . \*\*significant at  $p < 0.01$

Table 1 – Chemical structures and oxidation potentials ( $E_{p_{ox}}$ ) of the tested 2-SC and flavonoids.

Compound	Chemical structure	1 <sup>a</sup>	2 <sup>b</sup>	3 <sup>c</sup>	4 <sup>d</sup>	$E_{p_{ox}}$ (V) vs. Ag/AgCl	IC <sub>50</sub> ( $\mu\text{M}$ )	% effect
1A		0.01	0.01	0.01	0.01	0.45	100	100
1B		0.01	0.01	0.01	0.01	0.45	100	100
1C		0.01	0.01	0.01	0.01	0.45	100	100
1D		0.01	0.01	0.01	0.01	0.45	100	100
2A		0.01	0.01	0.01	0.01	0.45	100	100
2B		0.01	0.01	0.01	0.01	0.45	100	100
2C		0.01	0.01	0.01	0.01	0.45	100	100
2D		0.01	0.01	0.01	0.01	0.45	100	100
3A		0.01	0.01	0.01	0.01	0.45	100	100
3B		0.01	0.01	0.01	0.01	0.45	100	100
3C		0.01	0.01	0.01	0.01	0.45	100	100
3D		0.01	0.01	0.01	0.01	0.45	100	100

a) Not possible to determine  $E_{p_{ox}}$ .

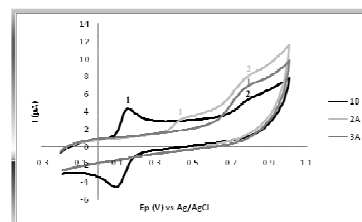


Fig. 1 – Cyclic voltammograms of the 2-SC 1B, 2A and 3A

The first oxidation peak observed in the 2-SC 1A-1D corresponds to the oxidation of the 3',4'-OH (catechol) moiety in the B-ring. A detailed analysis of this peak indicated a reversible redox process with a coupled chemical reaction. The mechanism beneath the reaction of catechol-like compounds with radical derivatives consists in a two electron two proton process with the production of an ortho-quinone (Fig 2a). However, our cyclic voltammetry results suggest an oxidation reaction involving only one electron process. This phenomenon can be explained by the formation of a semiquinone (SQ) (or to use the more generic term, an aryloxy radical), which undergoes disproportionation leading to the ortho-quinone formation and to the regeneration of the starting 2-SC (Fig 2b).

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