Asian Journal of Chemistry; Vol. 24, No. 12 (2012), 5746-5748

ASIAN JOURNAL OF CHEMISTRY

www.asianjournalofchemistry.co.in

Phytotoxic Effects of Non-ionic Surfactant Octylphenol Series (Triton X-100, Triton X-114, Triton X-405) on Onion†

FERUZAN DANE[1,*], GÜLDEN YILMAZ[1], HALIDE AKBAS[2], FATMANUR ÖZTÜRK[1] and SINEM LEVENTER[1]

[1]Trakya University, Faculty of Science, Department of Biology, Balkan Campus, 22030 Edirne, Turkey
[2]Trakya University, Faculty of Science, Department of Chemistry, Balkan Campus, 22030 Edirne, Turkey

*Corresponding author: E-mail: feruzandane@yahoo.com

AJC-11746

In this study, three widely used octylphenol series non-ionic surfactant Triton X-114, Triton X-100 and Triton X-405 were selected to examine their phytotoxic effects. They were evaluated under laboratory conditions using onion (*Allium cepa* L.) as a test material. The phytotoxic effects on root were determined after 7th days. Surfactants used in study were tested at three different surfactant concentrations, 5.00, 2.50 and 1.25 g/L (w/v) concentrations. The phytotoxicity results were based on the effective concentration that reduced root growth by 50 % (EC_{50}). Some differences were observed between the effects of three types of surfactants. Stimulatory effects only occurred in Triton X-405 while inhibitory effects occured in Triton X-100 and Triton X-114 at all concentrations. It was observed that inhibitory effects increased with increasing concentrations of Triton X-114 and Triton X-100.

Key Words: Onion, Effect, Triton X-100, Triton X-114, Triton X-405, Non-ionic surfactant.

INTRODUCTION

Surfactants are amphipathic molecules that alter the energy relationships at interfaces. They are frequently used in formulation and spray application of foliar-applied agrochemicals to improve performance of the active ingredient in crop production. There are non-ionic surfactants (no electrical charge), anionic surfactants and cationic surfactants[1]. Non-ionic surfactants are amphipathic molecules consisting of a hydrophobic (alkylated phenol derivatives, fatty acids, longchain linear alcohols, *etc.*) and a hydrophilic part (generally ethylene oxide chains of various length). Due to their favourable physicochemical properties, non-ionic surfactants are extensively used in many fields of technology and research. Non-ionic surfactants are an integral part of the majority of pesticide formulations[2]. They increase the leaf retention of spray solutions[3], enhance adhesional forces of aqueous droplets on crop leaf surfaces[4] and generally improve the effectiveness of active ingredients[5,6]. There are lots of studies about the effects of surfactants on plants[7-10].

The aim of this study was to investigate the phytotoxic effects on root growth for three different octylphenol series non-ionic surfactant, Triton X-114, Triton X-100, Triton X-405 non-ionic surfactant solutions under laboratory conditions using onion (*Allium cepa* L.) as a test material.

EXPERIMENTAL

In this study, three types of octylphenol (OP)-type surfactants, [4-(1,1,3,3-tetramethylbutyl)phenyl]-w-hydroxily-(oxy-l, 2-ethanediyl) prepared by condensing octylphenol with ethylene oxide (EO) were selected. Trade names for these non-ionic surfactants are, Triton X-114, Triton X-100 and Triton X-405 (Triton X also abbreviated TX) were used. These surfactants were selected because they represent important groups being used in pesticide formulation and in spray application of agrochemicals. Physical and chemical characteristics of the experimental surfactants are given in Tables 1-3.

The phytotoxic effects on root were determined after 7th days. Onion (*Allium cepa*) was selected as a material for this study. Because it grows rapidly and has got much absorbtion surface, onion is a good material for this study. *Allium cepa* L. is currently the third largest fresh vegetable industry in same places. All experiments were performed on primordial root of the onion. Healthy and equal-sized bulbs of common onion were used. Twelve onions composed an experimental set including three of them were control. Onions were placed individually in 60 mL vessels at the beginning of the experiment containing different surfactants. The temperature of the laboratory was kept at 16 ± 0.5 ºC. Three different surfactants concentrations (5.00 g/L, 2.50 g/L, 1.25 g/L) were prepared

†Presented at International Conference on Global Trends in Pure and Applied Chemical Sciences, 3-4 March, 2012; Udaipur, India

from stock solution (5 g surf./1000 mL) for each surfactant. Tap water was used in all surfactant solutions. Experiments were made 3 times. Root lengths were measured using a millimeter ruler starting at the onset of incubation, then after 1st, 2nd, 3rd, 4th, 5th, 6th and 7th days. At the end of the 7th day, the total root lengths were measured. Means and standard deviations of the length of onion root tips were determined. The phytotoxicity results were based on the effective concentration that reduced root growth by 50 % (EC_{50}).

TABLE-1
CHARACTERIZATION OF THE EXPERIMENTAL SURFACTANTS

Surfactant	Surfactant symbol	Structural formula
Polyoxyethylene octyl phenyl ether	TX-100	$(C_{14}H_{22}O[C_2H_4O]_{9-10})$
Polyethylene glycol *tert*-octylphenyl ether	TX-114	$(C_{14}H_{22}O[C_2H_4O]_{7-8})$
Octylphenol ethoxylate	TX-405	$(C_{14}H_{22}O[C_2H_4O]_{35-40})$

TABLE-2
PHYSICAL/CHEMICAL CHARACTERISTICS OF THE SURFACTANTS USED

	Triton® Nonionic Surfactant		
Property	X-114	X-100	X-405 (70 %)
Form	Liquid	Liquid	Aqueous solution
Average EO units	7-8	9-10	40
Active ingredient (%)	100 %	100 %	70 %
Colour, APHA	100	100	250
Specific Gravity, 25°/25°C	1.054 g/mL	1.065 g/mL	1.102 g/mL
Density, lb/gal	8.8	8.9	9.2
Viscosity, brook field, at 25 ºC, cP	260	240	490
Pour Point, ºF	15	45	25
Flash point, tag open cup, ºF	> 300	> 300	> 212
Cloud point, 1 % aqueous solution, ºC	22	65	> 100
HLB value (calculated)	12.4	13.5	17.9
Surface area, Angstrom	50	48-54	88
Critical micelle concentration	0.2 Mm	0.24 mM	-

TABLE-3
SOLUBILITY OF TRITON® OCTYLPHENOL SERIES AT ROOM TEMPERATURE(1)

	Triton® Surfactants		
Solvent	X-114	X-100	X-405
Water	D	M	M
Inorganic salt solutions	D	S	S
Aqueous mineral acids	S(2)	S	S
Polar organic solvents (alcohols, glycols, ethers, ketones, *etc.*)	M	M	M
Aromatic hydrocarbons	M	M	I
Aliphatic hydrocarbons	I	I	I

(1) I = insoluble; D = dispersible; M = miscible in all proportions; S = soluble; (2) Triton® X-114 is soluble in hydrochloric, phosphoric and dilute sulfuric acid solutions

A SPSS 19 statistical package was used to run statistical analysis. Conformance of the measurable data to the normal distribution was checked by single sample Kolmogorov Smirnov test. Kruskal-Wallis variance analysis and Mann Whitney U test were used in comparison between the groups not showing normal distribution. Median (Min-Max) values and arithmetical mean ± standard deviation were provided as descriptive statistic. Significance limit was specified as ($p \leq 0.05$) for all statistics. After Kruskal-Wallis variance analysis, in comparison of the results of Mann Whitney U, Benferroni correction was made.

RESULTS AND DISCUSSION

In this study, three widely used octylphenol series non-ionic surfactant TX-114, TX-100 and TX-405 were selected to examine their phytotoxic effects. Some differences were observed between the effects of three types of surfactants. As seen in Table-4, stimulatory effects only occurred in TX-405 while inhibitory effects occured in TX-100 and TX-114 at all concentrations. It was observed that inhibitory effects increased with increasing concentrations of TX-114 and Triton X-100 (Fig. 1). As (EC_{50}) concentration of TX-100 was found at 1,25 g/L concentration, (EC_{50}) concentration wasn't found for all concentration of TX-114. As seen as Fig. 1 and Table-4. TX-100 was more toxic than TX-114.

The direct effect of non-ionic surfactants on plant species has rarely been studied because surfactants generally contact plants in combination with various pesticides. However, there are some phytotoxic and inhibitory effects of different surfactants

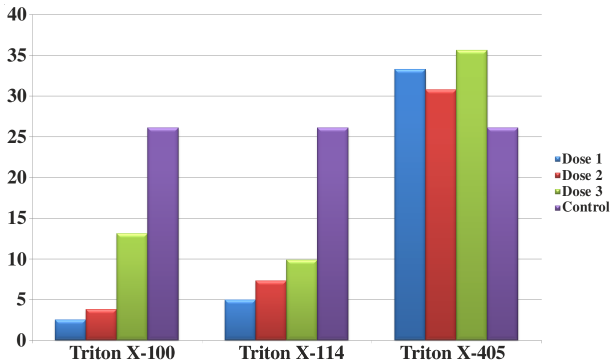

Fig. 1. Mean of root elongations effected by three surfactant solutions after 7 days: No. 1: (Triton X-100); No. 2: (Triton X-114); No. 3: (Triton X-405)

TABLE-4

Group	Root length Arithmetical mean ± SD, median, (min-max)
Control	13.30 ± 9.22, 11, (1-45)
Triton X-100 (5.00 g/L)	(*)4.14 ± 2.13, 4, (1-10)
Triton X-100 (2.50 g/L)	(*)7.67 ± 6.49, 5, (1-30)
Triton X-100 (1.25 g/L)	11.25 ± 6.48, 11, (1-30)
Triton X-114 (5.00 g/L)	(*)6.93 ± 4.82, 6, (1-47)
Triton X-114 (2.50 g/L)	(*)8.63 ± 5.08, 8, (1-25)
Triton X-114 (1.25 g/L)	(*)8.70 ± 5.87, 6, (1-27)
Triton X-405 (5.00 g/L)	(*)21.20 ± 17.31, 17, (1-70)
Triton X-405 (2.50 g/L)	(*)15.10 ± 9.35, 13, (1-40)
Triton X-405 (1.25 g/L)	(*)21.96 ± 17.63, 17 (1-65)

Each arithmetical mean value represents the mean of root elongations after a week treated with different three surfactants were given. (Triton X-100; Triton X-114; Triton X-405) (*) indicates significant differences at the 5% level between values obtained under control and treated plants ($P \leq 0.05$). Also, there were significant difference between (Triton X-100) and (Triton X-405) while there weren't any significant differences between (Triton X-100) and (Triton X-114) in plant systems include: repressed potassium uptake in barley by Tween-20 and Tween-80[11], decreased translocation of phosphorus in beans by Tween-80[12], decreased growth in tobacco by hexadecanol and docosanol[13], lowered germination in clover by Santomerse no. 1[14]. It was found that the toxicity of surfactants was about the number of the ethylene oxide groups and the hydrofobic state of the surfactant[15]. Surfactants also have shown some stimulatory effects. For instance, Tween-20 increased the hormonal activity in apple[16, 17]. Stimulatory effects were seen on the root elongation of *Allium cepa* L. treated by Brij 35[8], Brij 56, Brij 76, POE 10[7].

Non-ionic surfactants readily bind to various proteins and the binding modifies protein solubility and structure. These changes may also result in the stimulation or inhibition of the biological activity of enzymes[18]. The studies indicated that the effect of surfactant strongly depends on its concentration. Triton X- 100 stimulated the activity of the ATPase-active P-glycoprotein at low concentrations and inhibited it at higher concentrations[15,18]. In this study, it was found that TX-100 and TX-114 surfactants were very toxic for *Allium cepa*. Stimulatory effect of TX-405 was seen obviously while phytotoxic effect of TX-100 and TX-114 was determined. EC_{50} concentration of TX-100 was found at 1.25 g/L concentration. The effect depended on the number of ethylene oxide groups in the surfactant molecule[19]. Surfactants with more ethylene oxide groups showed lower toxicity toward *Mysidopsis bahia*[20]. Surfactants with low and high numbers of ethylene oxide groups were less effective[21]. It has been shown that the more hydrophilic surfactants (fewer ethylene oxide groups) had the smallest effect both on ethylene evolution and leaf growth in *Phaseolus vulgaris*[22]. Non-ionic surfactants considerably decreased the net potassium influx in roots of wheat seedlings; their effect depended on the number of ethylene oxide groups and on the overall hydrophobicity of the surfactant[23]. The pH of the solution did not significantly influence the sorption of octylphenoxy surfactants on isolated tomato fruit cuticles, indicating that ionic interactions have a negligible effect on sorption[24]. The toxicity of these surfactants to cowpea leaves was found to be inversely related to the length of the ethylene oxide chain[25]. A positive correlation was obtained between the degree of phytotoxicity and the hydrophilie-lipophilic balance (HLB) and partition coefficients for the Triton surfactants in Lemna minor[26]. In this study, physical and chemical characteristics of TX-100 was nearly the same as TX-114. Beacuse of that reason, they have the same phytotoxic and inhibitory effects on onion.

Consequently, the effects of surfactants have a marked impact on human health care, biotechnology, environmental protection and agrochemistry. It's important that determine (EC_{50}) concentration and concentrations, which are close to control values. In addition it must be selected appropriate surfactant, which has minimal toxicity and maximal benefits for each purpose.

REFERENCES

1. M.F. Rosen, Surfactants and Interfacial Phenomena, Wiley: New York, edn. 2 (1989).
2. D. Seaman, *Pestic. Sci.*, **29**, 437 (1990).
3. H. DeRuiter, A.J.M. Uffing, E. Meinen and A. Prins, *Weed Sci.*, **38**, 567 (1990).
4. T. Watanabe and I. Yamaguchi, *J. Pestic. Sci.*, **18**, 99 (1993).
5. J.D. Nalewaja, J. Palczinski and F.A. Manthey, *Weed Technol.*, **4**, 765 (1990).
6. J.D. Nalewaja, Z. Woznica and F.A. Manthey, *Weed Technol.*, **5**, 92 (1991).
7. G. Yilmaz, H. Akbas, F. Dane, S. Leventer and F. Öztürk, *Asian J. Chem.*, **24**, (2012) (in press).
8. H. Akbas, F. Dane, G. Yilmaz, F. Öztürk and S. Leventer, *Fresenius Environ. Bull.*, **21** (2012) (in press).
9. G. Yilmaz, F. Dane and F.N. Turan, *Fresenius Environ. Bull.*, **21** (2012) (in press).
10. F.D.H. Mcdowall, *Can. J. Bot.*, **41**, 1281 (1963).
11. J.F. Parr and A.G. Norman, *Plant Physiol.*, **39**, 502 (1964).
12. C.A. Swanson and J.B. Whitney, *Am. J. Bot.*, **40**, 816 (1953).
13. S.J. Bourget and E.V. Parups, *Soil Sci.*, **95**, 82 (1963).
14. E.C. Spurrier and J.A. Jacops, *Argon. J.*, **47**, 462 (1955).
15. T. Cserhati, *Environ. Health Perspect.*, **103**, 358 (1995).
16. C.P. Harley, H.H. Moon and L.O. Regeimbal, *Proc. Am. Soc. Hort. Sci.*, **69**, 21 (1957).
17. M.N. Westwood and L.P. Batjer, *Proc. Am. Soc. Hort. Sci.*, **76**, 16 (1960).
18. C.A. Doige, X. Yu and F.J. Sharom, *Biochim. Biophys. Acta*, **1146**, 65 (1993).
19. K. Benchekroun and R. Bonaly, *Appl. Microbiol. Biotechnol.*, **36**, 673 (1992).
20. W.S. Hall, J.B. Patoczka, R.J. Mirenda, B.A. Porter and E. Miller, *Arch. Environ. Contam. Toxicol.*, **18**, 765 (1989).
21. G. Oros, T. Cserhati and J. Szejtli, *Acta Argon. Hung*, **38**, 211 (1989).
22. M. Knoche and G.J. Noga, *Sci. Hortic.*, **46**, 1 (1991).
23. C. Bujtis, T. Cserhati and Z. Szigeti, *Biochem. Physiol. Pflanz.*, **183**, 277 (1988).
24. W.E. Schafer and M.J. Bukovac, *Plant Physiol.*, **85**, 965 (1987).
25. N.K. Lownds and M.J. Bukovac, *J. Am. Soc. Hort. Sci.*, **113**, 205 (1988).
26. P.Y. Caux, P. Weinberger and D.B. Carlisle, *Environ. Toxicol. Chem.*, **7**, 671 (1988).