ULTRASOUND ASSISTED DEGRADATION OF PHARMACEUTICALLY ACTIVE COMPOUNDS: EFFECT OF REACTOR DESIGN VARIABLES

Gangadhar Andaluri, Rominder P. S. Suri*, PhD, P.E.
Water and Environmental Technology Center, Temple University, Philadelphia, PA 19122
*Corresponding author email: rominder.suri@temple.edu

INTRODUCTION: Estrogen hormones have been detected in noteworthy concentrations in surface water, groundwater, wastewater, soils, and sediments [1]. These compounds interfere with the reproductive system. Detectable concentrations are discharged from treatment plants and observed in the receiving water bodies [2, 3]. The presence of estrogen compounds in natural systems leads to the necessity of developing effective treatment techniques, either as a supplement for conventional drinking water treatment systems to prevent potential risk to human health, or for conventional municipal and industrial wastewater treatment processes to decrease the pollution of PACs to the natural systems. Ultrasound has been shown to be an effective advanced water treatment technology for destruction of estrogen hormones [4]. This study examines the effect of various reactor design variables such as power density, ultrasound amplitude, reactor configuration, and mixing requirements on the destruction of several estrogen hormones.

***EXPERIMENTAL SECTION*:** The estrogen hormones included in this study are: 17•-estradiol, 17•-estradiol, estrone, estriol, 17•-dihydroequilin, 17•-ethinyl estradiol, and equilin. Batch experiments were conducted using a 2 kW ultrasound unit. Quantitative and qualitative analysis of estrogen hormones was performed using solid phase extraction followed by GC/MS instrument, and the methods have been published elsewhere [2, 5].

RESULTS AND DISCUSSIONS:

Effect of Mixing*:* Although sonication produces turbulence and mixing in the reactor, there is a possibility of having dead spots due to incomplete mixing in a reactor while sonicating an aqueous solution. To test the occurrence of a dead spot, mixing was introduced in to beakers of various sizes via a magnetic stirrer. Table 1 lists the percentage degradation of estrogen hormones with and without mixing. There was a significant effect observed on the degradation of estrogen hormones. The results show that dead spots can exist in the reactors and mixing is an effective way of removing the dead spots.

Table 1: Effect of Mixing on the degradation of estrogen hormones

Analyte	**Degradation Percentages**							
	1200 ml		**1400 ml**		**1600 ml**		**1800 ml**	
	NM	**M**	**NM**	**M**	**NM**	**M**	**NM**	**M**
17 • Estradiol	39	76	36	59	25	57	33	61
17 • Estradiol	46	77	40	55	26	55	36	59
17 • dihydroequilin	84	84	67	72	57	74	62	79
17 • Ethinylestradiol	0	61	24	43	NA	41	18	49
Estriol	34	64	14	32	21	31	17	35
Estrone	47	79	24	45	30	42	21	49
Equilin	60	79	43	53	39	48	31	54

NM: No mixing, M: with mixing

Effect of Power Density: Batch experiments were carried out using a 2 kW sonication unit by varying the volume of sample solution. The results show that for any particular reactor configuration, there exists an optimum volume where there is maximum degradation. Figure 1 shows the variation in degradation percentages of estrogen with variation in power density.

Effect of Ultrasound Amplitude: The effect of ultrasound amplitude was studied over a wide range of amplitudes (10µm - 96µm) using combination of various probes and boosters. A significant variation in the degradation of estrogens due to amplitude was observed. Different combination of probe and booster resulted in a different amplitude.

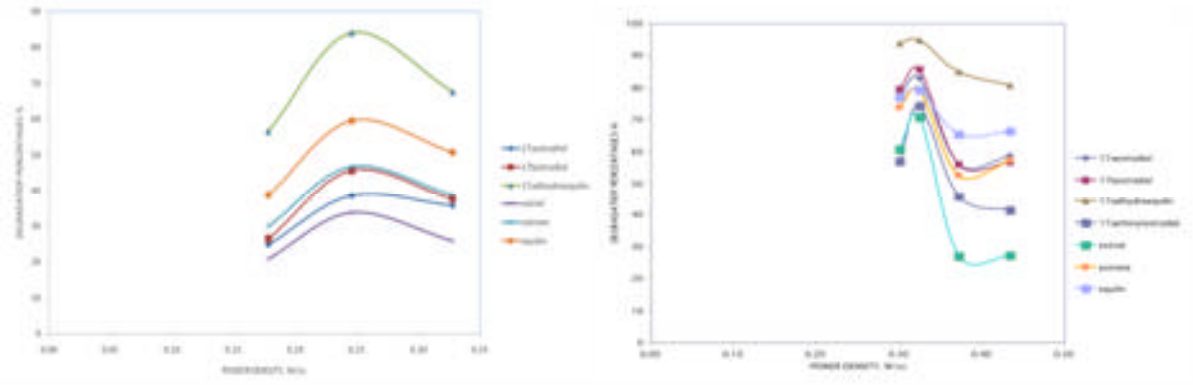

Figure 1: Effect of power density on degradation of estrogen hormones in two reactors

The combination of various reactor design variables (power density, power intensity, and ultrasound amplitude) will provide faster degradation kinetics. Further analysis of effect of various reactor design parameters on the degradation of estrogens is in progress.

Bibliography

1. Chimchirian, R.F., et al., *Presence of low-level free steroid estrogens in the surface water*, in *International Conference on Energy, Environment and Disasters*. 2005: Charlotte, NC, USA.
2. Chimchirian, R.F., R.P. Suri, and H. Fu, *Free synthetic and natural estrogen hormones in influent and effluent of three municipal wastewater treatment plants.* Water Environ Res, 2007. **79**(9): p. 969-74.
3. Andersen, H., et al., *Fate of estrogens in a municipal sewage treatment plant.* Environ Sci Technol, 2003. **37**(18): p. 4021-6.
4. Suri, R.P., et al., *Ultrasound assisted destruction of estrogen hormones in aqueous solution: effect of power density, power intensity and reactor configuration.* J Hazard Mater, 2007. **146**(3): p. 472-8.
5. Chimchirian, R.F., R.P.S. Suri, and J. Stofey, *Analysis of low level of free and conjugated synthetic and natural estrogen hormones in water and wastewater*, in *WEFTEC*. 2005: Washington D.C.