



**ENHANCEMENT OF DISSOLUTION RATE OF EFAVIRENZ  
EMPLOYING  $\beta$ -CYCLODEXTRIN, POLOXAMER 407 AND  
PVP K 30: A FACTORIAL STUDY**

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**ABSTRACT**

The objective of the study is to evaluate the individual main effects and combined (or interaction) effects of  $\beta$  cyclodextrin ( $\beta$ CD), surfactant (Poloxamer 407) and PVP K30 on the dissolution rate of efavirenz in a  $2^3$  factorial experiment. Solid inclusion complexes of efavirenz- $\beta$ CD were prepared with and without Poloxamer 407 and PVP K30 by kneading method as per  $2^3$ -factorial design and were evaluated. ANOVA indicated that the individual main effects of  $\beta$ CD, Poloxamer 407 and PVP K30 and their combined effects in enhancing the solubility and dissolution rate ( $K_1$ ) were highly significant ( $P < 0.01$ ). Combination of  $\beta$ CD with Poloxamer 407 and PVP K30 gave significantly higher dissolution rates ( $K_1$ ) when compared to  $\beta$ CD alone.  $\beta$ CD alone gave 3.98 fold increase and in combination with Poloxamer 407 and PVP K 30, it gave respectively 5.38 and 6.87 fold increase in the dissolution rate of efavirenz. Poloxamer 407 and PVP K30 alone also gave a higher enhancement in the dissolution rate of efavirenz. Hence a combination of  $\beta$ CD with Poloxamer 407 and / or PVP K30 or Poloxamer 407 and PVP K30 alone is recommended to enhance the dissolution rate of efavirenz a BCS class II drug.

**Key words:** Efavirenz,  $\beta$  Cyclodextrin, Poloxamer 407, PVP K30, Dissolution rate,

Factorial Study

**INTRODUCTION**

Efavirenz, a widely prescribed HIV- 1 specific non – nucleoside reverse transcriptase inhibitor drug belongs to

class II under BCS and exhibit low and variable oral bioavailability due to its poor aqueous solubility. It is practically insoluble in water and aqueous fluids. As such its oral absorption is dissolution rate

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limited and it requires enhancement in solubility and dissolution rate for increasing its oral bioavailability. Several techniques<sup>1</sup> such as micronization, cyclodextrin complexation, use of surfactants and solubilizers, solid dispersion in water soluble and dispersible carriers, use of salts, prodrugs and polymorphs which exhibit high solubility, micro emulsions and self emulsifying micro and nano disperse systems have been used to enhance the solubility, dissolution rate and bioavailability of poorly soluble drugs. Among the various approaches complexation with cyclodextrins has gained good acceptance in recent years in industry for enhancing the solubility and dissolution rate of poorly soluble drugs. Cyclodextrins (CDs) are cyclic torus-shaped molecules with a hydrophilic outer surface and a lipophilic central cavity which can accommodate a variety of lipophilic drugs. As a consequence of inclusion process many physico-chemical properties such as solubility, dissolution rate, stability and bioavailability can be favourably affected<sup>2,3</sup>. Cyclodextrins have been receiving increasing application in pharmaceutical formulation in recent years due to their approval by various regulatory agencies<sup>4,5</sup>. Poloxamer 407 is a polyethylene oxide - polypropylene oxide - polyethylene oxide triblock co-polymer of non-ionic nature and is used as a solubilising agent<sup>6-8</sup>. Poly vinyl pyrrolidone (PVP K 30) is also reported<sup>9,10</sup> to enhance the solubility and dissolution rate of poorly soluble drugs. Though cyclodextrin complexation and use of surfactants and PVP for enhancing the solubility and dissolution rate of poorly soluble drugs have been investigated individually, no reports are available on their combined use in enhancing the solubility and dissolution rate. In the present investigation the individual main effects and combined (or interaction) effects of  $\beta$  cyclodextrin ( $\beta$ CD), surfactant

(Poloxamer 407) and PVP K30 on the dissolution rate of efavirenz, a BCS class II drug were evaluated in a 2<sup>3</sup> factorial study.

## EXPERIMENTAL

### Materials

Efavirenz was a gift sample from M/s. Eisai Pharmatechnology and Manufacturing Pvt. Ltd., Visakhapatnam.  $\beta$  Cyclodextrin was gift sample from M/s. Cerestar Inc., USA. Methanol (Qualigens), poly vinyl pyrrolidone (PVP K30) and Poloxamer 407 were procured from commercial sources. All other materials used were of pharmacopoeial grade.

### Methods

#### Estimation of Efavirenz

A UV Spectrophotometric method based on the measurement of absorbance at 245 nm in water containing 2 % Sodium lauryl sulphate (SLS) was used for the estimation of efavirenz. The method was validated for linearity, accuracy, precision and interference. The method obeyed Beer's law in the concentration range of 0-10  $\mu$ g/ml. When a standard drug solution was repeatedly assayed (n=6), the relative error and coefficient of variance were found to be 0.85% and 1.20 % respectively. No interference by the excipients used in the study was observed.

#### Preparation of Efavirenz - $\beta$ CD Complexes

Solid inclusion complexes of efavirenz -  $\beta$ CD - Poloxamer 407 - PVP K30 were prepared as per 2<sup>3</sup> - factorial study by kneading method. Efavirenz,  $\beta$ CD, Poloxamer 407 and PVP K30 were triturated in a mortar with a small volume of solvent consisting of a blend of water: methanol (1:1). The thick slurry formed was kneaded for 45 min and then dried at

55°C until dry. The dried mass was powdered and sieved to mesh No. 120.

### Dissolution Rate Study

The dissolution rate of efavirenz as such and from  $\beta$ CD complexes prepared was studied in 900 ml water containing 2 % Sodium lauryl sulphate (SLS) using Disso 2000 (Labindia) 8-station dissolution test apparatus with a paddle stirrer at 50 rpm. A temperature  $37 \pm 1^\circ\text{C}$  was maintained throughout the study. Efavirenz or efavirenz-  $\beta$ CD complex equivalent to 100 mg of efavirenz was used in each test. Samples of dissolution media (5 ml) were withdrawn through a filter ( $0.45 \mu$ ) at different intervals of time, suitable diluted and assayed for efavirenz at 245 nm. The sample of dissolution fluid withdrawn at each time was replaced with fresh fluid. The dissolution experiments were replicated three times each ( $n=3$ ).

### Analysis of Data

Dissolution data were analyzed by Analysis of Variance (ANOVA) as per  $2^3$  factorial studies.

## RESULTS AND DISCUSSION

To evaluate the individual and combined effects of  $\beta$ CD, Poloxamer 407 and PVP K30 on the dissolution rate of efavirenz, solid inclusion complexes of efavirenz-  $\beta$ CD were prepared with and without Poloxamer 407 and PVP K30 as per  $2^3$ -factorial design. For this purpose two levels of  $\beta$ CD (0 and 1:2 ratio of drug :  $\beta$ CD) and two levels of each of Poloxamer 407 and PVP K30 (0 and 2%) were selected and the corresponding eight treatments involved in the  $2^3$ -factorial study were efavirenz pure drug (1); efavirenz-  $\beta$ CD (1:2) inclusion binary complex (a); efavirenz - Poloxamer 407 (2%) binary complex (b); efavirenz-  $\beta$ CD (1:2) - Poloxamer 407 (2%) ternary complex (ab); efavirenz - PVP K30 (2%) binary complex (c); efavirenz-  $\beta$ CD (1:2) -

PVP K30 (2%) ternary complex (ac); efavirenz - Poloxamer 407 (2%) - PVP K30 (2%) ternary complex (bc) and efavirenz- $\beta$ CD (1:2) - Poloxamer 407 (2%) - PVP K30 (2%) complex (abc). The CD complexes were prepared by kneading method. All the solid inclusion complexes of efavirenz-  $\beta$ CD - Poloxamer 407 /PVP K30 prepared were found to be fine and free flowing powders. Low coefficient of variation (c.v.) values ( $< 1.2 \%$ ) in the percent drug content indicated uniformity of drug content in each batch of solid inclusion complexes prepared. The dissolution rate of efavirenz alone and from  $\beta$ CD complexes was studied in water containing 2 % SLS as prescribed in IP 2010.

The dissolution of efavirenz followed first order kinetics with  $r$  (correlation coefficient) above 0.9150. Dissolution efficiency ( $DE_{30}$ ) values were calculated as suggested by Khan<sup>11</sup>. The dissolution parameters are given in Table-1. The dissolution of efavirenz was rapid and higher in the case of efavirenz-  $\beta$ CD binary and ternary complex systems prepared when compared to efavirenz pure drug as such. The dissolution profiles are given in Fig-1. The dissolution rate ( $K_1$ ) values were subjected to ANOVA to find out the significance of the main and combined effects of  $\beta$ CD, Poloxamer 407 and PVP K30 on the dissolution rate of efavirenz. ANOVA indicated (Table 2) that the individual main effects of  $\beta$ CD, Poloxamer 407 and PVP K30 and their combined effects in enhancing the dissolution rate ( $K_1$ ) were highly significant ( $P < 0.01$ ).  $\beta$ CD alone gave a 3.98 fold increase in the dissolution rate of ( $K_1$ ) of efavirenz.

When  $\beta$ CD is combined with Poloxamer 407 and PVP K30 the dissolution rate ( $K_1$ ) was significantly enhanced. A 5.38 and 6.87 fold increase in the dissolution rate ( $K_1$ ) was observed

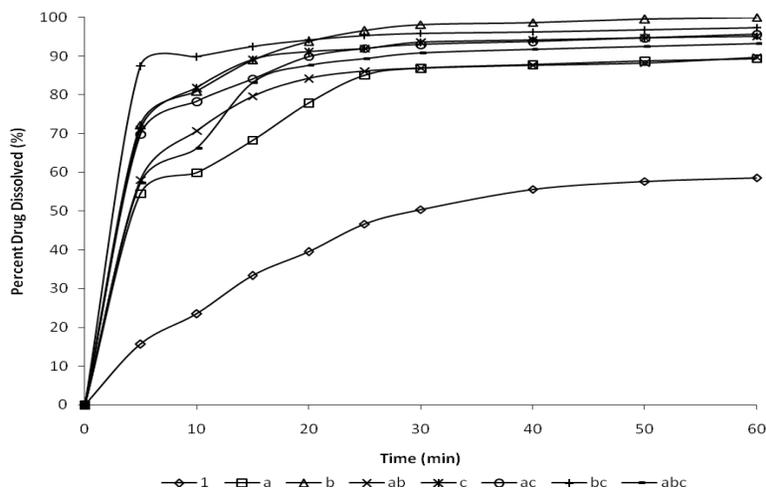
respectively with efavirenz-  $\beta$ CD – Poloxamer 407 and efavirenz-  $\beta$ CD – PVP K30 solid inclusion complexes. Poloxamer 407 ( $F_b$ ) and PVP K30 ( $F_c$ ) alone and in combination ( $F_{bc}$ ) also gave 8.0 – 8.9 fold

increase in the dissolution rate ( $K_1$ ) of efavirenz.  $DE_{30}$  values were also much higher in the case of  $\beta$ CD – Poloxamer 407 – PVP K 30 solid complexes when compared to efavirenz pure drug.

**Table 1: Dissolution Parameters of Efavirenz- $\beta$ CD– Pol 407 – PVP K30 Complexes Prepared as per  $2^3$  Factorial Study**

EF-CD Complexes	Composition	PD <sub>10</sub> (%)	$K_1 \times 10^2$ (min <sup>-1</sup> )	Increase in $K_1$ (no.of folds)	DE <sub>30</sub> (%)	Increase in DE <sub>30</sub> (no.of folds)
$F_1$	EF	23.5	1.25	-	30.6	-
$F_a$	EF - $\beta$ CD (1:2)	60.0	4.98	3.98	64.8	2.1
$F_b$	EF - P 407 (2%)	80.9	11.16	8.93	80.18	2.6
$F_{ab}$	EF - $\beta$ CD (1:2) - P 407 (2%)	70.7	6.73	5.38	69.86	2.3
$F_c$	EF - PVP (2%)	81.8	10.01	8.00	70.66	2.3
$F_{ac}$	EF - $\beta$ CD (1:2) - PVP (2%)	78.3	8.59	6.87	76.69	2.5
$F_{bc}$	EF - P 407 (2%) - PVP (2%)	89.8	10.28	8.22	84.45	2.8
$F_{abc}$	EF - $\beta$ CD (1:2) - P 407(2%) - PVP (2%)	66.2	7.86	6.29	72.89	2.4

EF - Efavirenz;  $\beta$ CD - Cyclodextrin; P 407 - Poloxamer 407; PVP - Poly vinyl pyrrolidone K 30



**Fig.1: Dissolution Profiles of Efavirenz –  $\beta$ CD Complexes Prepared by Employing  $\beta$ CD, Poloxamer 407 and PVP K30 as per  $2^3$  Factorial Design**

**Table 2: ANOVA of Dissolution Rate of Efavirenz –  $\beta$ CD- Poloxamer 407- PVP K30 Solid Inclusion Complexes Prepared as per  $2^3$  Factorial Study**

Source of Variation	D.F	S.S	M.S.S	F-Ratio	Significance
Total Treatments	23 7	0.01728 0.01684	0.000751 0.00241	88.25	P<0.01
a	1	0.00060	0.00060	22.04	P<0.01
b	1	0.00355	0.00355	130.36	P<0.01
ab	1	0.00352	0.00352	128.95	P<0.01
c	1	0.00382	0.00382	140.94	P<0.01
ac	1	0.00025	0.00025	9.32	P<0.01
bc	1	0.00344	0.00344	126.30	P<0.01
abc	1	0.00165	0.00165	60.57	P<0.01
Error	16	0.000436	0.000027		

$F_{0.01(7,16)} = 4.03$ ;  $F_{0.05(7,16)} = 2.66$ ;  $F_{0.01(1,16)} = 8.53$ ;  $F_{0.05(1,16)} = 4.49$

### CONCLUSION

The individual and combined effects of  $\beta$ CD, Poloxamer 407 and PVP K30 in enhancing the dissolution rate of efavirenz were highly significant ( $P < 0.01$ ). Combination of  $\beta$ CD with Poloxamer 407 and PVP K30 gave significantly higher dissolution rates ( $K_1$ ) when compared to  $\beta$ CD alone.  $\beta$ CD alone gave 3.98 fold increase and in combination with Poloxamer 407 and PVP K 30, it gave

respectively 5.38 and 6.87 fold increase in the dissolution rate of efavirenz. Poloxamer 407 and PVP K30 alone also gave a higher enhancement in the dissolution rate of efavirenz. Hence a combination of  $\beta$ CD with Poloxamer 407 and / or PVP K30 or Poloxamer 407 and PVP K30 alone is recommended to enhance the dissolution rate of efavirenz, a BCS class II drug.

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