



# Preparation and characterization of polymeric micelles (SNEDDS) containing curcumin

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## Abstract

The polymeric micelles (SNEDDS) containing curcumin (C<sub>Q10</sub>) were prepared by solvent evaporation method. The micelles were characterized by UV–vis, FT-IR, ATR, and DLS. The micelles were found to be spherical in shape and the diameter was in the range of 100–200 nm. The micelles were found to be stable in water and the stability was evaluated by DLS. The micelles were found to be stable in water and the stability was evaluated by DLS. The micelles were found to be stable in water and the stability was evaluated by DLS.

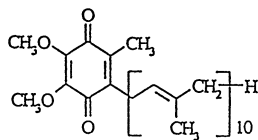
**Keywords:** C<sub>Q10</sub>; E; S; SNEDDS; T; B.V.

## 1. Introduction

Curcumin (C<sub>Q10</sub>) (Fig. 1), a natural polyphenolic compound, has been found to have a wide range of biological activities. It is a powerful antioxidant and has been shown to have anti-inflammatory, anti-cancer, and anti-aging properties.

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D (G. . . ., 1992).



2.2. Methods

2.2.1. Differential scanning calorimetry (DSC) of CoQ<sub>10</sub>-menthol and CoQ<sub>10</sub>-essential oil binary systems.

C Q<sub>10</sub> L- 90:10 10:90 ( / ). A  
 5  
 (DSC 7, P E  
 N (CT). T  
 25 60 C  
 10 C -1. S  
 C Q<sub>10</sub> 80:20  
 20:80 ( / ) 37 C.  
 R 4 C 24  
 C Q<sub>10</sub>. T  
 10  
 DSC  
 DSC. F C Q<sub>10</sub>  
 80:20 60 40 ( / ),  
 25 55 C.  
 S  
 10 C -1. L  
 10 C -1. L  
 (I 2, P E ).

2.2.2. Determination of CoQ<sub>10</sub> melting time

C Q<sub>10</sub>  
 50 60% /  
 M (I R -G, T 37 C  
 T, C ). C EL  
 20, 40 60% /  
 (M, G I, M, WI)  
 V.  
 A 24  
 37 C. S

2.2.3. Formulation of the self-emulsified systems

A  
 (37.5 60%), EL (0 62.5%),  
 MCM-C8 (0 62.5%). T  
 C Q<sub>10</sub> 50:50. C Q<sub>10</sub>  
 37 C. C EL MCM-C8  
 W  
 C Q<sub>10</sub>  
 30 4 HPMC  
 F

2.2.4. Visual observations

T  
 (50 ) 37 C  
 100 E  
 25 C  
 T  
 J  
 J (C, 1995; K  
 , 2001). P  
 A

2.2.5. Emulsion droplet size analysis and turbidity measurements

F (50 ) 37 C  
 37 C, 100  
 E  
 T

2.2.5.1. Droplet size analysis. T

C  
 (M LS230, M, FL),  
 0.04 2000 μ . T  
 S

6 (U( 286. (6 .U( 286.P)087.. )-7( )-286. )-286.9 7) T0 -1.2 0 TD

(New England  
E600 P, New England  
CCD (H... HV-C20, H...  
A... L... S... D... CA). T...  
T...  
(C...  
MP4R, I... E... C...  
N... H... MA) 0.5–1... 3000  
(RCF... 500 × g). U...  
16 MΩ... H... 4... T...  
100 μ... 1... 5...  
B...

2.2.

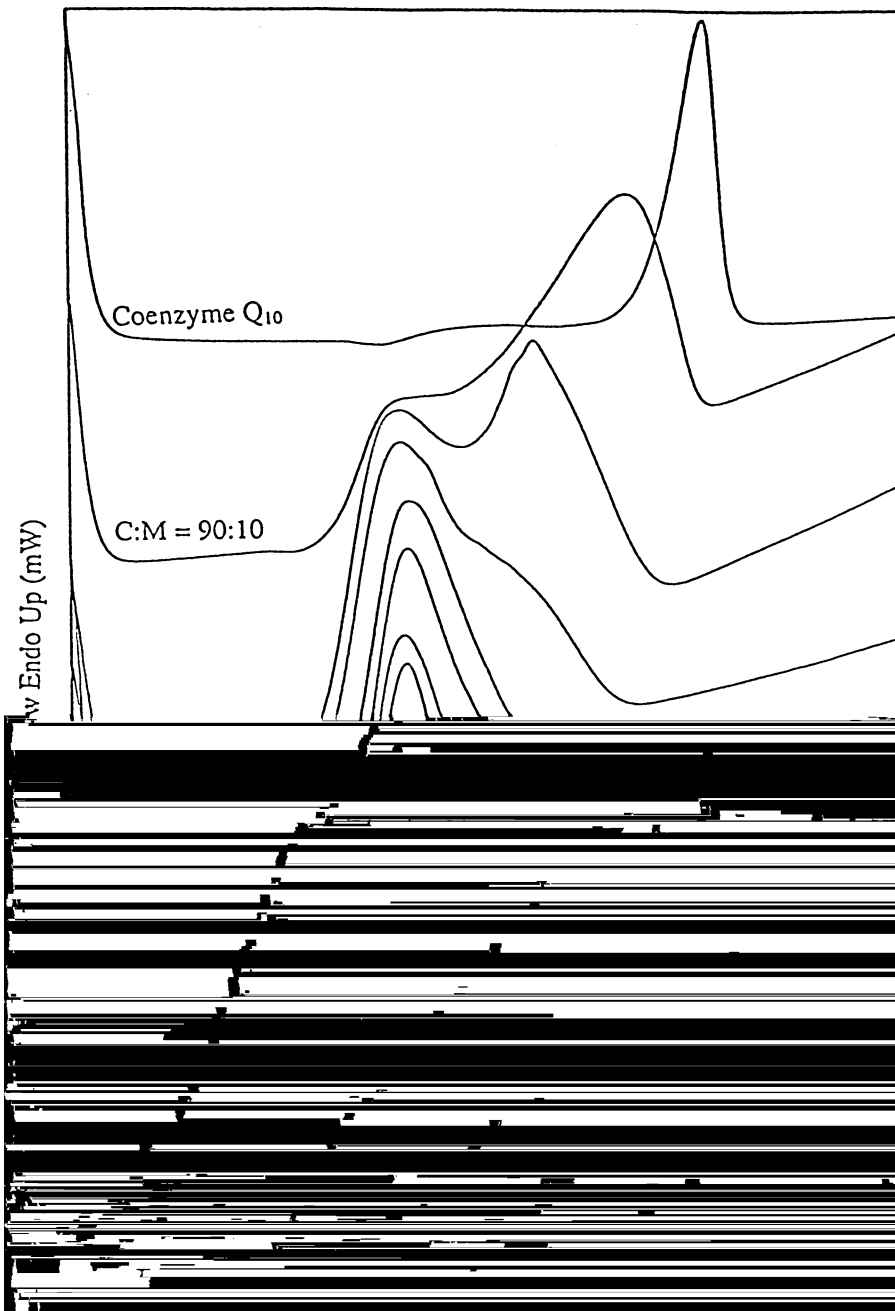


Fig. 2. DSC thermograms of pure Coenzyme Q<sub>10</sub> (A) and 90:10 C:M formulation (B–E) at heating rates of 10, 20, 30, and 40 °C/min, respectively.

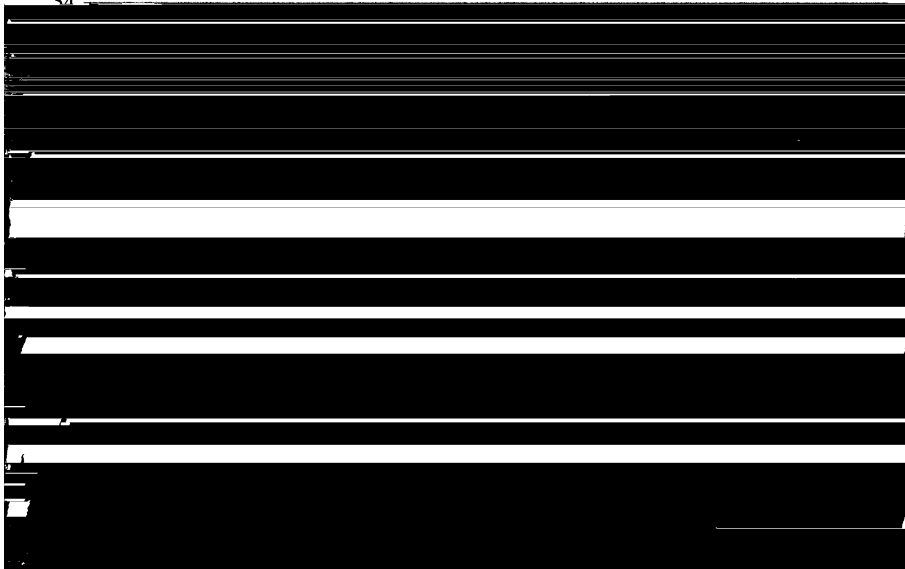
P450 (B) (Nazzari et al., 1998). A

E

C Q<sub>10</sub> 37 C.

T 1 F  
D  
C Q<sub>10</sub> (K  
EL  
, 2001)  
C Q<sub>10</sub>  
T  
C Q<sub>10</sub>  
EL 37 C W 60%  
EL  
50 60% / C Q<sub>10</sub>  
5.3 1.8 P  
C Q<sub>10</sub> EL  
T  
A  
50% / C Q<sub>10</sub>  
5  
I  
C Q<sub>10</sub>

54



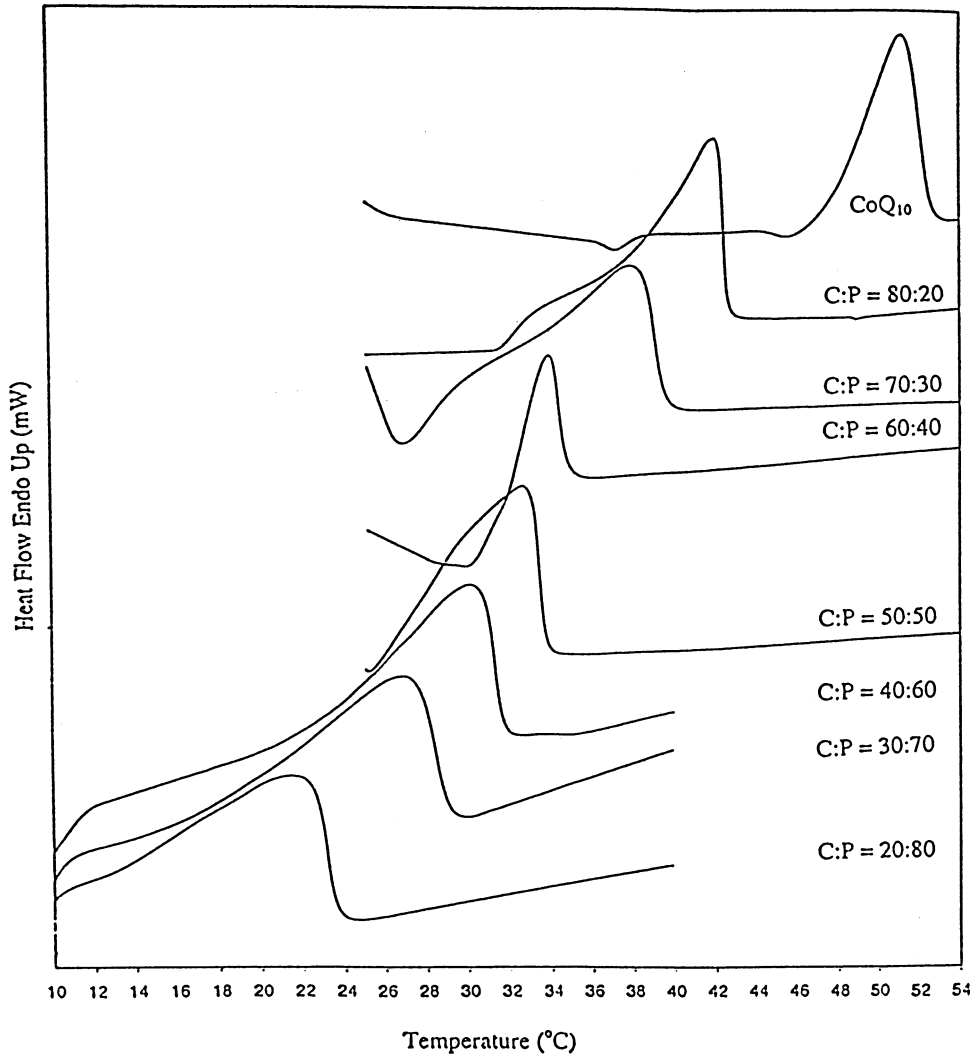


Fig. 4. DSC

CoQ<sub>10</sub>

R

W  
T  
37.5%  
T  
1,  
C Q<sub>10</sub> 63%  
(R, 1975).  
3.4. Droplet size analysis and turbidity measurements  
(C, S, 1997). C



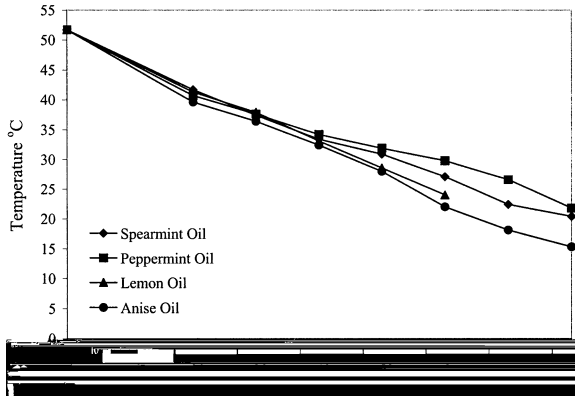


Fig. 5. Thermogram of the essential oils (DSC).  
C Q<sub>10</sub>

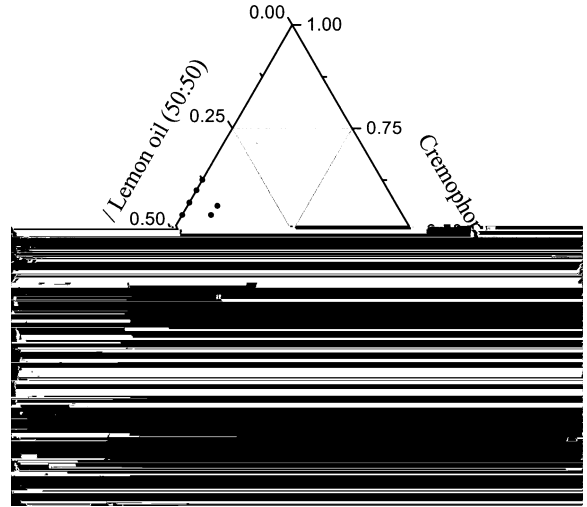


Fig. 6. Phase diagram of the essential oils (P).

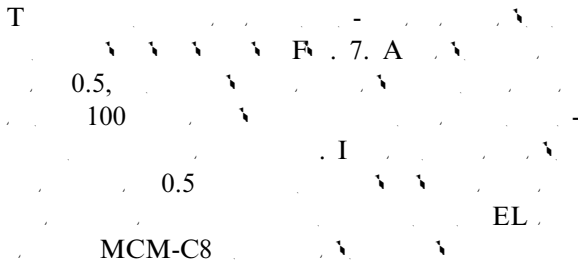


Fig. 7. A graph showing the relationship between temperature (T) and other variables (I).  
MCM-C8 EL

G... (1998)  
-355, EL,  
2:1. I  
(C  
S..., 1997; G..., 1998). C  
.6( )-3 .6( )4763.1( )-.8( ) T6S

T.E.F	2	SNEDDS		C (%) /		C		M		S		SNEDDS		D (μ)		D(0.9)
		C	Q10	L	W	L	W	C	Q10	M	S	D(0.1)	D(0.25)	D(0.5)	D(0.75)	
1		18.8	18.8	18.8	56.3	6.3	2.817	0.270	3.179	3.014	2.806	2.619	2.468			
2		18.8	18.8	18.8	50.0	12.5	0.402	0.277	0.845	0.572	0.323	0.117	0.110			
3		18.8	18.8	18.8	43.8	18.8	0.121	0.015	0.142	0.130	0.119	0.100	0.101			
4		18.8	18.8	18.8	37.5	25.0	0.112	0.037	0.165	0.135	0.106	0.084	0.070			
5		18.8	18.8	18.8	31.3	31.3	0.090	0.012	0.107	0.099	0.089	0.081	0.045			
6		18.8	18.8	18.8	25.0	37.5	0.113	0.017	0.137	0.125	0.112	0.100	0.092			
7		18.8	18.8	18.8	18.8	43.8	<0.040									
8		20.0	20.0	20.0	53.3	6.7	0.845	0.308	1.287	1.027	0.786	0.607	0.499			
9		20.0	20.0	20.0	46.7	13.3	0.725	0.213	1.031	0.862	0.693	0.558	0.472			
10		20.0	20.0	20.0	40.0	20.0	0.121	0.048	0.170	0.141	0.110	0.083	0.067			
11		20.0	20.0	20.0	33.3	26.7	0.089	0.026	0.107	0.098	0.089	0.081	0.074			
12		20.0	20.0	20.0	26.7	33.3										
13								0.025	0.117	0.107	0.099	0.091				

0.06781735 0 TD20.037.5 0.02.995 0 TD20.0

0.10158.8(3.179)-30002.8(0.862)-3292.4(0.119)-3101.3(0.084) T10-5.024 0 TD 7130.1125

(G. M., 1974).  
 $\tau = Kmw^2$   
 $K = \frac{2\pi^2 n^2}{M}$   
 M, 1974; P., 1985). (G.  
 T.  
 NTU  
 P. (1985)  
 H., NTU  
 T.

0–1 NTU (H. A., 1998).

3.5. Fourier transform-infrared spectroscopy (FT-IR)

T.  
 ATR (H. J., 1999). C Q<sub>10</sub>  
 FT-IR.  
 A. C Q<sub>10</sub>  
 F. 8. C Q<sub>10</sub>  
 (29) 50:50 C Q<sub>10</sub> T  
 F. 8, C Q<sub>10</sub>  
 C Q<sub>10</sub> L  
 C Q<sub>10</sub>

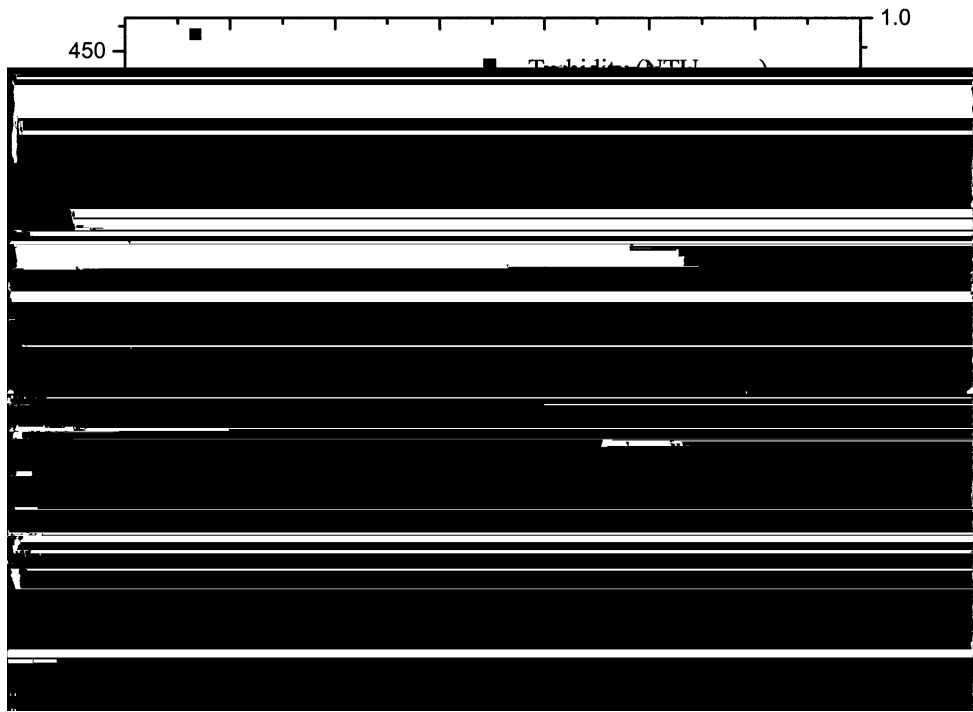


Fig. 7. E (EL) and (MCM-C8) NTU.

T	E	SNEDDS	L	C	C	NTU	NTU	NTU	P	STD
F		SNEDDS	(% / )							
		C Q10								
1		18.8	18.8	56.3	6.3	605.5				
2		18.8	18.8	50.0	12.5	220.0	78.2	70.7	94.0	2.18
3		18.8	18.8	43.8	18.8	25.1	8.9	19.5	90.3	7.87
4		18.8	18.8	37.5	25.0	9.0	3.2	6.0	92.8	2.52
5		18.8	18.8	31.3	31.3	6.9	2.5	4.8	88.8	2.52
6		18.8	18.8	25.0	37.5	5.3	1.9	4.1	88.0	2.84
7		18.8	18.8	18.8	43.8	2.4	0.8	3.1	87.4	4.42
8		20.0	20.0	53.3	6.7	513.0				
9		20.0	20.0	46.7	13.3	207.0	69.0	51.7	85.0	1.14
10		20.0	20.0	40.0	20.0	32.7	10.9	13.8	87.3	1.14
11		20.0	20.0	33.3	26.7	12.0	4.0	5.7	91.0	5.35
12		20.0	20.0	26.7	33.3	7.0	2.3	3.5	96.3	1.28
13		20.0	20.0	20.0	40.0	4.5	1.5	3.0	99.5	0.64
14		21.4	21.4	50.0	7.1	510.5				
15		21.4	21.4	42.9	14.3	90.1	28.0	52.0	89.8	3.98
16		21.4	21.4	35.7	21.4	20.1	6.2	10.3	94.7	0.05
17		21.4	21.4	28.6	28.6	10.6	3.3	4.1	94.7	1.12
18			21.4	21.4	35.7	5.9	1.8	2.7		





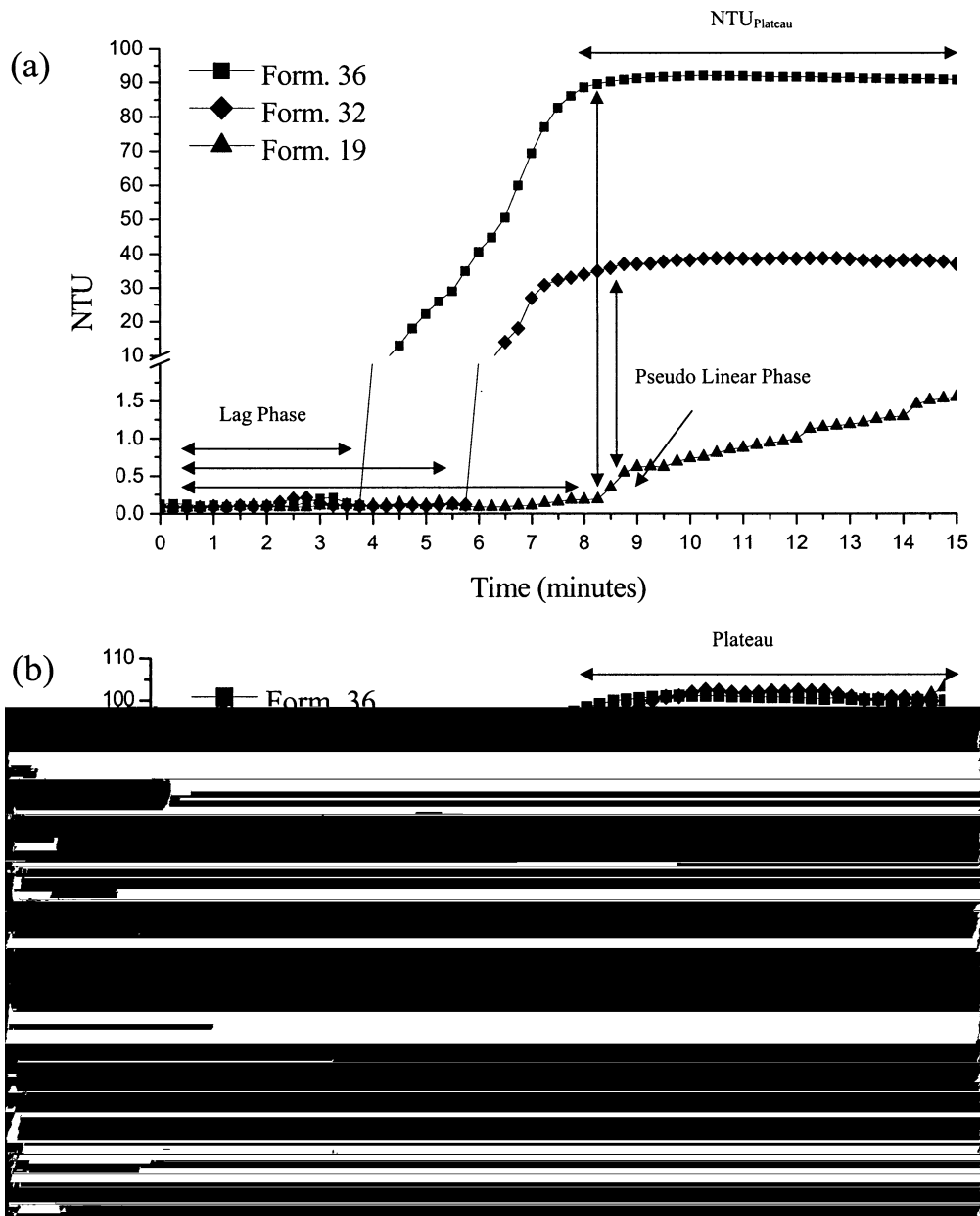
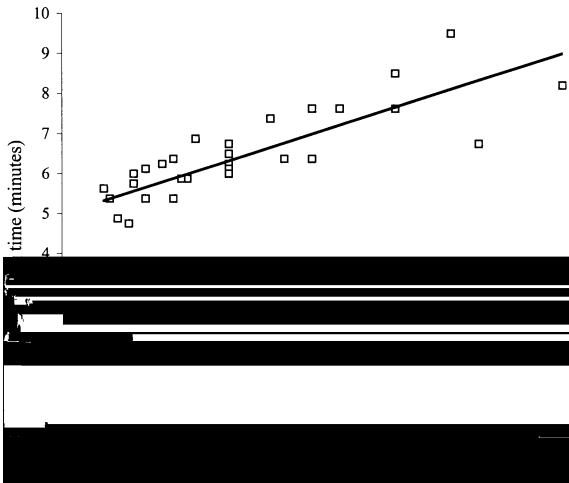


Fig. 9. (a) T<sub>90</sub> vs Time.

A 1:1:3  
 F . 11  
 (K , 1983). F . 11  
 (B , 1991). F . 11  
 T  
 P  
 (K L , 1983). H  
 (G G , 1976).



F . 10. E ( EL)

NTU NTU  $t_{NTU} \times 100/$   
 100%  
 C Q<sub>10</sub> (F . 9) .  $t_{NTU}$   
 t. G  
 F . 9 , A  
 T  
 (E ) T  
 F . 12  
 M  
 1 HLB 42.6%. T B  
 (1997) HLB  
 H  
 (S , 1994). A  
 1996). T (H

**4. Conclusion**

T  
 SNEDDS. P SNEDDS  
 C Q<sub>10</sub>. R  
 HPMC T



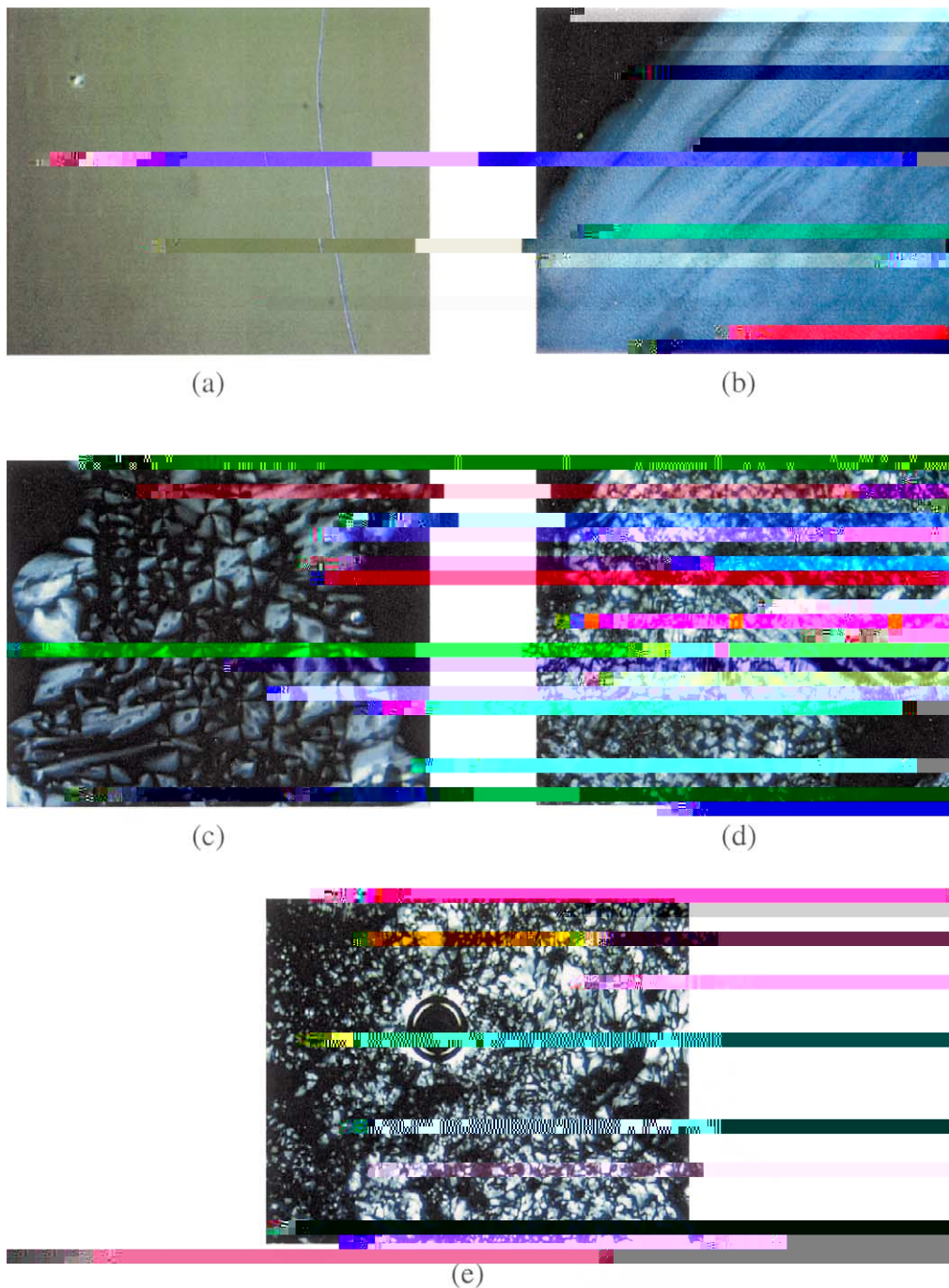


Fig. 11. (C)  $O_3$ ,  $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_4$ ,  $A_5$ ,  $A_6$ ,  $A_7$ ,  $A_8$ ,  $A_9$ ,  $A_{10}$ ,  $A_{11}$ ,  $A_{12}$ ,  $A_{13}$ ,  $A_{14}$ ,  $A_{15}$ ,  $A_{16}$ ,  $A_{17}$ ,  $A_{18}$ ,  $A_{19}$ ,  $A_{20}$ ,  $A_{21}$ ,  $A_{22}$ ,  $A_{23}$ ,  $A_{24}$ ,  $A_{25}$ ,  $A_{26}$ ,  $A_{27}$ ,  $A_{28}$ ,  $A_{29}$ ,  $A_{30}$ ,  $A_{31}$ ,  $A_{32}$ ,  $A_{33}$ ,  $A_{34}$ ,  $A_{35}$ ,  $A_{36}$ ,  $A_{37}$ ,  $A_{38}$ ,  $A_{39}$ ,  $A_{40}$ ,  $A_{41}$ ,  $A_{42}$ ,  $A_{43}$ ,  $A_{44}$ ,  $A_{45}$ ,  $A_{46}$ ,  $A_{47}$ ,  $A_{48}$ ,  $A_{49}$ ,  $A_{50}$ ,  $A_{51}$ ,  $A_{52}$ ,  $A_{53}$ ,  $A_{54}$ ,  $A_{55}$ ,  $A_{56}$ ,  $A_{57}$ ,  $A_{58}$ ,  $A_{59}$ ,  $A_{60}$ ,  $A_{61}$ ,  $A_{62}$ ,  $A_{63}$ ,  $A_{64}$ ,  $A_{65}$ ,  $A_{66}$ ,  $A_{67}$ ,  $A_{68}$ ,  $A_{69}$ ,  $A_{70}$ ,  $A_{71}$ ,  $A_{72}$ ,  $A_{73}$ ,  $A_{74}$ ,  $A_{75}$ ,  $A_{76}$ ,  $A_{77}$ ,  $A_{78}$ ,  $A_{79}$ ,  $A_{80}$ ,  $A_{81}$ ,  $A_{82}$ ,  $A_{83}$ ,  $A_{84}$ ,  $A_{85}$ ,  $A_{86}$ ,  $A_{87}$ ,  $A_{88}$ ,  $A_{89}$ ,  $A_{90}$ ,  $A_{91}$ ,  $A_{92}$ ,  $A_{93}$ ,  $A_{94}$ ,  $A_{95}$ ,  $A_{96}$ ,  $A_{97}$ ,  $A_{98}$ ,  $A_{99}$ ,  $A_{100}$ . (O)  $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_4$ ,  $A_5$ ,  $A_6$ ,  $A_7$ ,  $A_8$ ,  $A_9$ ,  $A_{10}$ ,  $A_{11}$ ,  $A_{12}$ ,  $A_{13}$ ,  $A_{14}$ ,  $A_{15}$ ,  $A_{16}$ ,  $A_{17}$ ,  $A_{18}$ ,  $A_{19}$ ,  $A_{20}$ ,  $A_{21}$ ,  $A_{22}$ ,  $A_{23}$ ,  $A_{24}$ ,  $A_{25}$ ,  $A_{26}$ ,  $A_{27}$ ,  $A_{28}$ ,  $A_{29}$ ,  $A_{30}$ ,  $A_{31}$ ,  $A_{32}$ ,  $A_{33}$ ,  $A_{34}$ ,  $A_{35}$ ,  $A_{36}$ ,  $A_{37}$ ,  $A_{38}$ ,  $A_{39}$ ,  $A_{40}$ ,  $A_{41}$ ,  $A_{42}$ ,  $A_{43}$ ,  $A_{44}$ ,  $A_{45}$ ,  $A_{46}$ ,  $A_{47}$ ,  $A_{48}$ ,  $A_{49}$ ,  $A_{50}$ ,  $A_{51}$ ,  $A_{52}$ ,  $A_{53}$ ,  $A_{54}$ ,  $A_{55}$ ,  $A_{56}$ ,  $A_{57}$ ,  $A_{58}$ ,  $A_{59}$ ,  $A_{60}$ ,  $A_{61}$ ,  $A_{62}$ ,  $A_{63}$ ,  $A_{64}$ ,  $A_{65}$ ,  $A_{66}$ ,  $A_{67}$ ,  $A_{68}$ ,  $A_{69}$ ,  $A_{70}$ ,  $A_{71}$ ,  $A_{72}$ ,  $A_{73}$ ,  $A_{74}$ ,  $A_{75}$ ,  $A_{76}$ ,  $A_{77}$ ,  $A_{78}$ ,  $A_{79}$ ,  $A_{80}$ ,  $A_{81}$ ,  $A_{82}$ ,  $A_{83}$ ,  $A_{84}$ ,  $A_{85}$ ,  $A_{86}$ ,  $A_{87}$ ,  $A_{88}$ ,  $A_{89}$ ,  $A_{90}$ ,  $A_{91}$ ,  $A_{92}$ ,  $A_{93}$ ,  $A_{94}$ ,  $A_{95}$ ,  $A_{96}$ ,  $A_{97}$ ,  $A_{98}$ ,  $A_{99}$ ,  $A_{100}$ . (□)  $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_4$ ,  $A_5$ ,  $A_6$ ,  $A_7$ ,  $A_8$ ,  $A_9$ ,  $A_{10}$ ,  $A_{11}$ ,  $A_{12}$ ,  $A_{13}$ ,  $A_{14}$ ,  $A_{15}$ ,  $A_{16}$ ,  $A_{17}$ ,  $A_{18}$ ,  $A_{19}$ ,  $A_{20}$ ,  $A_{21}$ ,  $A_{22}$ ,  $A_{23}$ ,  $A_{24}$ ,  $A_{25}$ ,  $A_{26}$ ,  $A_{27}$ ,  $A_{28}$ ,  $A_{29}$ ,  $A_{30}$ ,  $A_{31}$ ,  $A_{32}$ ,  $A_{33}$ ,  $A_{34}$ ,  $A_{35}$ ,  $A_{36}$ ,  $A_{37}$ ,  $A_{38}$ ,  $A_{39}$ ,  $A_{40}$ ,  $A_{41}$ ,  $A_{42}$ ,  $A_{43}$ ,  $A_{44}$ ,  $A_{45}$ ,  $A_{46}$ ,  $A_{47}$ ,  $A_{48}$ ,  $A_{49}$ ,  $A_{50}$ ,  $A_{51}$ ,  $A_{52}$ ,  $A_{53}$ ,  $A_{54}$ ,  $A_{55}$ ,  $A_{56}$ ,  $A_{57}$ ,  $A_{58}$ ,  $A_{59}$ ,  $A_{60}$ ,  $A_{61}$ ,  $A_{62}$ ,  $A_{63}$ ,  $A_{64}$ ,  $A_{65}$ ,  $A_{66}$ ,  $A_{67}$ ,  $A_{68}$ ,  $A_{69}$ ,  $A_{70}$ ,  $A_{71}$ ,  $A_{72}$ ,  $A_{73}$ ,  $A_{74}$ ,  $A_{75}$ ,  $A_{76}$ ,  $A_{77}$ ,  $A_{78}$ ,  $A_{79}$ ,  $A_{80}$ ,  $A_{81}$ ,  $A_{82}$ ,  $A_{83}$ ,  $A_{84}$ ,  $A_{85}$ ,  $A_{86}$ ,  $A_{87}$ ,  $A_{88}$ ,  $A_{89}$ ,  $A_{90}$ ,  $A_{91}$ ,  $A_{92}$ ,  $A_{93}$ ,  $A_{94}$ ,  $A_{95}$ ,  $A_{96}$ ,  $A_{97}$ ,  $A_{98}$ ,  $A_{99}$ ,  $A_{100}$ . (○)  $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_4$ ,  $A_5$ ,  $A_6$ ,  $A_7$ ,  $A_8$ ,  $A_9$ ,  $A_{10}$ ,  $A_{11}$ ,  $A_{12}$ ,  $A_{13}$ ,  $A_{14}$ ,  $A_{15}$ ,  $A_{16}$ ,  $A_{17}$ ,  $A_{18}$ ,  $A_{19}$ ,  $A_{20}$ ,  $A_{21}$ ,  $A_{22}$ ,  $A_{23}$ ,  $A_{24}$ ,  $A_{25}$ ,  $A_{26}$ ,  $A_{27}$ ,  $A_{28}$ ,  $A_{29}$ ,  $A_{30}$ ,  $A_{31}$ ,  $A_{32}$ ,  $A_{33}$ ,  $A_{34}$ ,  $A_{35}$ ,  $A_{36}$ ,  $A_{37}$ ,  $A_{38}$ ,  $A_{39}$ ,  $A_{40}$ ,  $A_{41}$ ,  $A_{42}$ ,  $A_{43}$ ,  $A_{44}$ ,  $A_{45}$ ,  $A_{46}$ ,  $A_{47}$ ,  $A_{48}$ ,  $A_{49}$ ,  $A_{50}$ ,  $A_{51}$ ,  $A_{52}$ ,  $A_{53}$ ,  $A_{54}$ ,  $A_{55}$ ,  $A_{56}$ ,  $A_{57}$ ,  $A_{58}$ ,  $A_{59}$ ,  $A_{60}$ ,  $A_{61}$ ,  $A_{62}$ ,  $A_{63}$ ,  $A_{64}$ ,  $A_{65}$ ,  $A_{66}$ ,  $A_{67}$ ,  $A_{68}$ ,  $A_{69}$ ,  $A_{70}$ ,  $A_{71}$ ,  $A_{72}$ ,  $A_{73}$ ,  $A_{74}$ ,  $A_{75}$ ,  $A_{76}$ ,  $A_{77}$ ,  $A_{78}$ ,  $A_{79}$ ,  $A_{80}$ ,  $A_{81}$ ,  $A_{82}$ ,  $A_{83}$ ,  $A_{84}$ ,  $A_{85}$ ,  $A_{86}$ ,  $A_{87}$ ,  $A_{88}$ ,  $A_{89}$ ,  $A_{90}$ ,  $A_{91}$ ,  $A_{92}$ ,  $A_{93}$ ,  $A_{94}$ ,  $A_{95}$ ,  $A_{96}$ ,  $A_{97}$ ,  $A_{98}$ ,  $A_{99}$ ,  $A_{100}$ . (●)  $A_1$ ,  $A_2$ ,  $A_3$ ,  $A_4$ ,  $A_5$ ,  $A_6$ ,  $A_7$ ,  $A_8$ ,  $A_9$ ,  $A_{10}$ ,  $A_{11}$ ,  $A_{12}$ ,  $A_{13}$ ,  $A_{14}$ ,  $A_{15}$ ,  $A_{16}$ ,  $A_{17}$ ,  $A_{18}$ ,  $A_{19}$ ,  $A_{20}$ ,  $A_{21}$ ,  $A_{22}$ ,  $A_{23}$ ,  $A_{24}$ ,  $A_{25}$ ,  $A_{26}$ ,  $A_{27}$ ,  $A_{28}$ ,  $A_{29}$ ,  $A_{30}$ ,  $A_{31}$ ,  $A_{32}$ ,  $A_{33}$ ,  $A_{34}$ ,  $A_{35}$ ,  $A_{36}$ ,  $A_{37}$ ,  $A_{38}$ ,  $A_{39}$ ,  $A_{40}$ ,  $A_{41}$ ,  $A_{42}$ ,  $A_{43}$ ,  $A_{44}$ ,  $A_{45}$ ,  $A_{46}$ ,  $A_{47}$ ,  $A_{48}$ ,  $A_{49}$ ,  $A_{50}$ ,  $A_{51}$ ,  $A_{52}$ ,  $A_{53}$ ,  $A_{54}$ ,  $A_{55}$ ,  $A_{56}$ ,  $A_{57}$ ,  $A_{58}$ ,  $A_{59}$ ,  $A_{60}$ ,  $A_{61}$ ,  $A_{62}$ ,  $A_{63}$ ,  $A_{64}$ ,  $A_{65}$ ,  $A_{66}$ ,  $A_{67}$ ,  $A_{68}$ ,  $A_{69}$ ,  $A_{70}$ ,  $A_{71}$ ,  $A_{72}$ ,  $A_{73}$ ,  $A_{74}$ ,  $A_{75}$ ,  $A_{76}$ ,  $A_{77}$ ,  $A_{78}$ ,  $A_{79}$ ,  $A_{80}$ ,  $A_{81}$ ,  $A_{82}$ ,  $A_{83}$ ,  $A_{84}$ ,  $A_{85}$ ,  $A_{86}$ ,  $A_{87}$ ,  $A_{88}$ ,  $A_{89}$ ,  $A_{90}$ ,  $A_{91}$ ,  $A_{92}$ ,  $A_{93}$ ,  $A_{94}$ ,  $A_{95}$ ,  $A_{96}$ ,  $A_{97}$ ,  $A_{98}$ ,  $A_{99}$ ,  $A_{100}$ .



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