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Induced Antiferroelectric Phases in Multicomponent Systems*

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Ma e al w h u ced a fe elec c h a e (S C_A^*) c ed f c e h a cl c (S C_β^*) h al (S A) h a e h a e bee u d ed. T h e c h a ac e a - ol ded f le f l h a u e , e e e , h e h ld, au a a d h ld l a e , e cale, a c a d d a c c a a a d c e a le be wee (+) a d (–) fe elec c a e . T h e u e A_{70}-B_{30} h wed V- h a ed (h e h ldle) w c h , w h le h e u e 1_{15}-C_{85} h wed a h e h ld w h a b ad h e e u e f a e a fe elec c .

Key words: ec c h u d c al, u ced a cl c ec c h a e, a fe elec c , elec c e e f u ced a fe elec c

T h e d c e f a e h e h ld a fe elec c h u d c al a d h e V- h a ed (h e h ldle) w c h ec c b h u da' ea (ee e ew a e [1,2]) all wed h e de f d la h a ed ew a le a d e le el c h a ac e c . S wa clea h e ece f u h e ea c h f ew l ed ec c a e al b a ea e a e f e e , h a h e a e al c u ld be be e ada ed d ffe e a l ca . Rece l e f u b e ed h a a a cl c (a fe elec c) S C_A^* LC h a e a be u ced b c e - e , c ed u l a e u l f a c h al c u d w h a u a ed e al c h a a d a c h al c u d w h a a ed e al c h a [3,4]. T h e al h e b l f f u la u l c e a fe elec c S C_A^* u e f c u d h a cl c a d h al ec c h a e . S c h b l wa w h h e .

I h w , h e elec - cal c h a ac e a d a c a d a c c d f w e f u ced a fe elec c u l c e u e e e ed. T h e f u ec a e ce f u a ed c e a d h e ec d ec a e ce f a ed c e . T h e a wa b a u da e al f a abu h e elec - cal be h a u a d ec e h e e alu e f l e d la a l ca .

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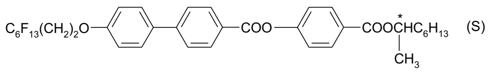
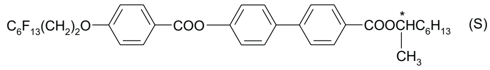
*Ded ca ed h e e f P fe K f P .

EXPERIMENTAL

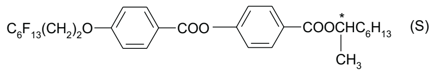
Compounds and mixtures. The fl a ed c e ha e he f ll w u u e:



C$_1$ 80.7 C 98.1 S C$^*_\beta$ 148.1 S A 183.6 I **1**
3.02 *4.60* *0.20* *1.13*



C$_1$ 94.3 C 97.9 S C$^*_\beta$ 155.6 S A 184.6 I **2**
0.6 *5.05* *0.36* *1.31*



C 60.0 S A 63.4 I **3**
5.90 *0.74*

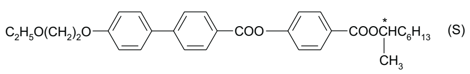
Pha e a a e e °C, a d a e hal e cal/ l (*italic*).

The he f c u d **1** a d **2** a d al **4** a d **5** wa ece l de c bed [5]. X- a u d e f he ec u d la e ac da a a d c f a f he ha e de f ca we e e e ed [6,7]. The a e ab e c e f ece eau e e b a ed w h a ew, h hl ec e SETARAM 141 DSC u e f ew e a ed c u d .

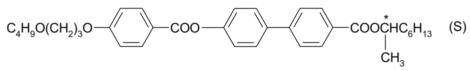
C u d **1** a d **2** ha e b h he a e al cl c ec c C$^*_\beta$ (c f ed b d elec c e u d e [8]) a d h al ec c A ha e, b he d ffe ab l u ce he a fe elec c ha e w h a a ed a e . C u d **1** u ce C$^*_A$ ha e e ha c u d **2** [3]. The w - c u d **3** d e u ce h ha e, b acu e u ch ab l u e w h c u d **1** a d **2**. The e e ce f c u d **3** all w dec ea e f he el f he u ec c.

The calu la ed c f he u ec c f **1**, **2** a d **3** he f ll w : **1** – 21.78 w . %; **2** – 34.97 w . % a d **3** – 43.25 w . % (u e A). M u e A h wed he ha e a : C 49°C S C* 93°C S A 134°C I u he ea a d c all ed a abu 36°C u c l .

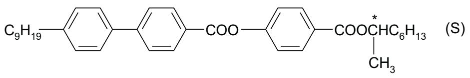
The a ed c e ha e he f ll w u u e a d ha e a :



C 102.8 (S I$^*_A$ 90.2) S A 148.5 I **4**
5.92 *1.52* *1.72*

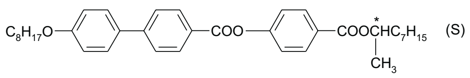


C 91.9 (S A 88.3) I **5**
9.86 *1.32*



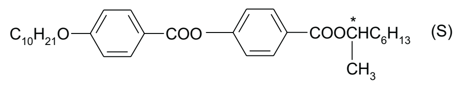
C 63.0 S X 72.2 S C$^*_\gamma$ 74.0 S C$^*_\beta$ 76.7
6.48 *0.008* *0.0002* *0.0002*

S C$^*_\alpha$ 79.6 S A 106.9 I **6**
0.004 *1.30*



C$_1$ 57.8 C 79.8 (S I$^*_A$ 64.9) S C$^*_\beta$ 118.8
1.79 *5.59* *0.23* *0.03*

S C$^*_\alpha$ 119.4 S A 144.0 I **7**
0.01 *1.42*



C 31.6 (N 21.9) I [9] **8**
7.65 *1.24*

C u d 4 ha a e a c ec c A ha e, a d a c S I_A^* ha e, c u d 5 ha a c ec c A ha e l, a d c u d 8 ha l a c e a c ha e. C u d 6 ha h ee S C^* u b ha e, S A ha e a d a e de f ed S X ha e bel w 72°C. A e e we w f c b l e ha S X a S C_A^* ha e. The c u d u de e a b d f- fe e e h d.

C u d 7 ha ec c I_A^* a d A ha e a d w u b ha e C_α^* a d C_β^*. Th c u d wa e ed [10] h a h a S C* ha e b a e e au e we e e he e. Tw u ec c c - we e calu la ed a d e a ed: B ec c B c ed c u d 4 a d 5 h e a u 47.23 w.% f 4 a d 52.77 w.% f 5 h wed he ha e a : C 70°C S A 120°C I a d c all ed d c l a 35°C. B ec c C c a ed c u d 4, 5, 6, 7 a d 8 w h we h e ce a e 13.99, 9.27, 38.22, 18.52 a d 20.0 e ec el. The ha e a f u e C we e: C 14 15°C S C_β^* 55°C S A 84 101°C I. I c all ed a abu 4 5°C. The ec c S I_A^* wa b e ed h e e u e. The e e au e a de hal f ha e a f d d al c u d we e eau ed b a SETARAM 141 DSC cal e e. Ph a e d a a f A-B a d 1-C e we e b a ed b h e l e c ce a e h d *via* we h a e a a ed a le f abu 0.02 f each c ce a. The e e au e f ha e a we e eau ed w h a LINKAM THMS 600 h a e a d a BIOLAR PZO l a cal c c e. Pha e we e de f ed b c c c b e a. Cu d c al u e we e laced be wee h c c e la e w h u ace.

Cell preparation and electro-optical characterization. The elec - cal (EO) e e f e- a ed a e al we e cha ac e ed b e fe e e. S a ca u a - a c be ha u a d ffe e e e au e d ded h alf c e a le be wee fe elec c (+) a d (–) a e, elec - cal e e (cal h e e u e) a l H a u la wa e f , c a a a d h e h ld l a e. D a c be h a u d ded e e (e a d fall) e , e cal e a d d a c c a a . F h e ee e - e , h e cell we e d e e h e b le la al e a u a e u l e b a l ed wa e- f ec f call de el ed f a fe elec c a d V- h a ed a e al [11]. Cell a be wee 1.6 1.9 we e u ed. N l -6 (Ald ch) wa u ed a al e a e al u f 2,2,2,- ch l e h a l w h h ee d ffe e c ce a (/l): 7.20, 14.4, 21.6 (h e e f al e de- ed a e, a a d f e ec el f h e e c ce a). The al e h e be EO e e a l w e e au e e f d a c add e , wh le ee a e u a e c a wa elec ed f each u e. @ e wa al wa 4 h a 160°C. The al e la e we e de ed b a e e au e. The e eed wa 3500 all ca e. S e wa 30, 40, a d 50 f la e e, a, a d f e ec el. Pla a a allel (↑↑) al e wa u ed all ca e.

RESULTS AND DISCUSSION

Phase transitions in multicomponent systems A-B and 1-C. The h a e d a a f h e e c ed f l a ed u e A a d a ed u e B h w F u e 1. The h a e d a a f h e e c ed f c u d 1 a d a ed u e C h w F u e 2.

The a le we e laced be wee c c c l de w h u e la e a d ace. The l we e e au e f c all a A-B u e we e fu d h e a e f h h e c ce a f l a ed c u d, wh le 1-C u e h e we e fu d h e a e f h h e c ce a f a ed c u d.

The d ced a fe elec c S C_A^* h a e b e ed A-B e f h e c - ce a a e 20 75 w.% f B. I h e al ab l h h e (abu 75°C) f c ce a 40 50 w.% f B, a d dec ea e h a l f h h e a d l we B c - ce a. M u e A-B w h B c ce a be wee 20 a d 40 w.% ca be u e c led bel w e au e. The h a e d a a (F u e 1) cl e h e h a e d a a f h e b c e e 1 4 de c bed [3]. H we e, h e b-

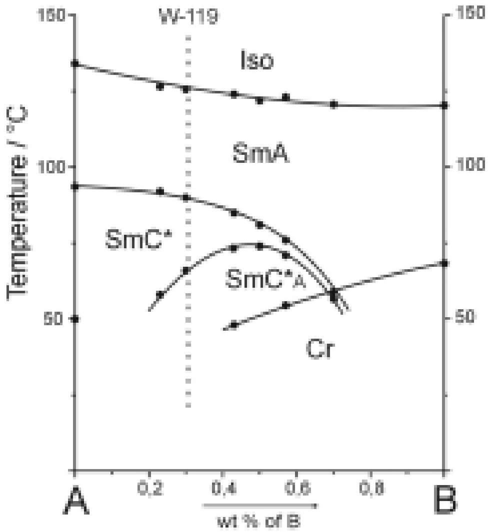


Figure 1. Ph a e d a a f u l c e u e A-B. T a e e au e f h ea c cle a e e .

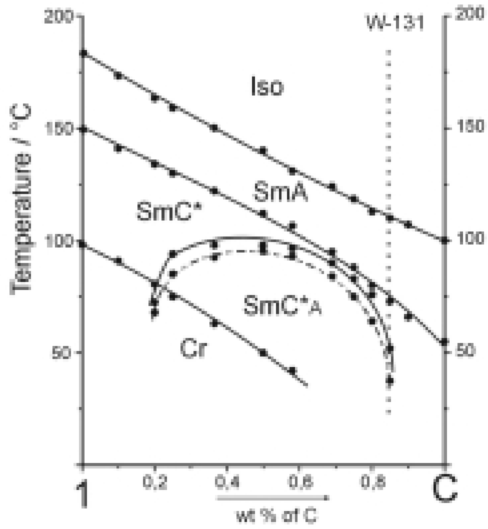
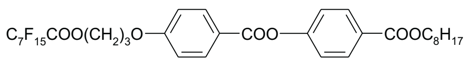


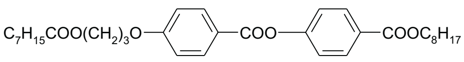
Figure 2. Ph a e d a a f u l c e u e 1-C. T a e e au e f h ea c cle a e e . B e l e f S C_A^* a f c l added.

e ed a u f S C_A^* h a e wa 120°C h a ca e. The u ced S C_A^* h a e b e ed h e 1-C e a c ce a 20 85 w . % f C. The h a e e a e e au e a h h a 100°C (F u e 2). The al ab l l wea l de e de c ce a w h h e a e 25 70% w . f C; h we e dec ea e a d l u - de h a e. M u e A-B c a 70 w . % f l a ed c e A a d 30 w . % f a ed c e B, (a ed a W-119 u e) a d u e 1-C c - a 15 w . % f l a ed c u d 1 a d 85 w . % f a ed u e C

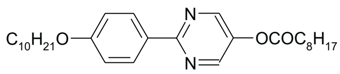
(a ed a W-131) we e elec ed f u f he h cal a d elec - cal u d e . Du c l he u e W-119 h wed he f ll w ha e a : C 13°C S C_A^* 61.5°C S C_β^* 90.5°C S A 109- 125.6°C I ; d hea u e W-119 he a S C_A^* → S C_β^* wa b e ed a h he e e e a u e (66.5°C). M u e W-119 wa d ed w h ach al c u d **9** hea u f 20 w . % w h c - u d **10** **11** **12** e a a el hea u 10 w . %. The e u l u e we e called W-119a, b, c, a d d e ec el .



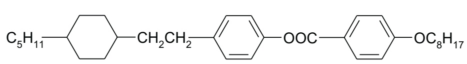
C 83.3 – 84.5 (S C 71.0 S A 76.4) I **9**
10.95 *0.08* *1.40*



C_1 53.4 C 56.4 (S A 32.8) I **10**
1.14 *11.56*



C_1 51.7 C 65.6 S C 95.0 N 96.2 I **11**
1.02 *7.88* *1.16* *1.14*



C 67.3 (S I_A 56.0) S C 85.6 N 156.7 I **12**
8.10 *0.99* *0.10* *0.69*

I u e W-119a, b a d c, h a ll he a cl c S C_A^* ha e, a b h e e f he al ab l wa b e ed d c c c b e a . S ch be ha - u wa b e ed al b c e e a d ee be a c h a ac e c fea- u e f he d ced a cl c ha e [3,4].

M u e W-119a, b, c a d d h wed he f ll w ha e e u e ce d c l- (←) a d hea (→):

M u e	P ha e a /°C
W-119a	C $\overleftarrow{4}$ S C_A^* $\overleftarrow{57.3}$ ($\overrightarrow{65}$) S C_β^* $\overleftarrow{86}$ S A $\overleftarrow{100}$ I
W-119b	C $\overleftarrow{10}$ S C_A^* $\overleftarrow{45}$ ($\overrightarrow{56.6}$) S C_β^* $\overleftarrow{82}$ S A $\overleftarrow{94}$-117 I
W-119c	C $\overleftarrow{0}$ S C_A^* $\overleftarrow{44}$ ($\overrightarrow{54}$) S C_β^* $\overleftarrow{90.5}$ S A $\overleftarrow{106}$-123 I
W-119d	C $\overleftarrow{15}$ S C_β^* $\overleftarrow{93.7}$ S A $\overleftarrow{108}$-127 I

The d a **9**, **10**, **11**, **12** dec ea e he ab l f S C_A^* ha e u e W-119 he f ll w wa :

12 > 11 > 10 > 9

The ach al e e **12,** ha a l ed ec c C ha e, u e ed he a fe elec c ha e u e W-119 a c ce a ab e 5 w . %, wh le he fl a ed e e **9** h wed al fl e ce he ab l f h ha e e e a c ce a u 20 w . %. I a ed a al u e **10** dec ea ed he ab l f S C_A^* u ch e, ea l he a e wa a d e **11** d d, e a dle c u d **10** h a l h - al ec c A h a e w h h e l w clea , wh le **11** h a he l ed h a e C. The u e W-131 had h a e a : C 7 S C_A^* 37 (52) S C_β^* 70 S A 95-110 I .

Temperature dependence of tilt angle. F u e 3 h w h e e e au e de e d- e ce f h e h alf-c e a le (θ) eau ed be wee (+) a d(–) fe elec c a e f u e W-119 a d W-131. The c e d de e de ce f u e W-119a, b, c a d d h w F u e 4.

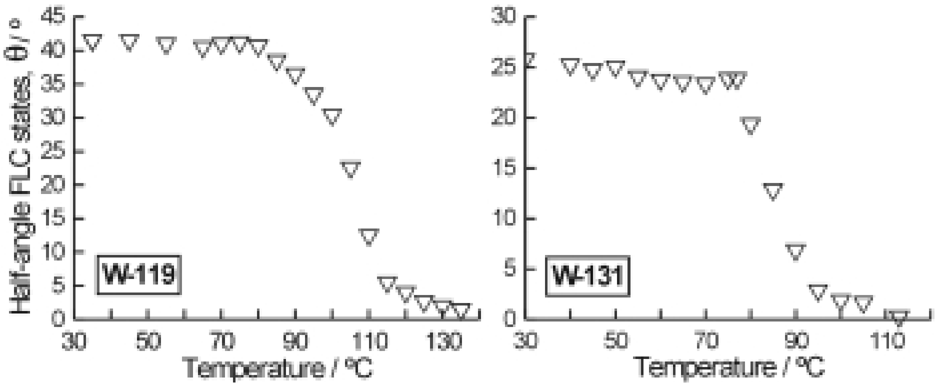


Figure 3. Half-c e a le be wee (+) a d(–) fe elec c a e f u e 119 a d W-131u e - e au e. Cell 1.8 ; a u la 1 H wa ef a l ed.

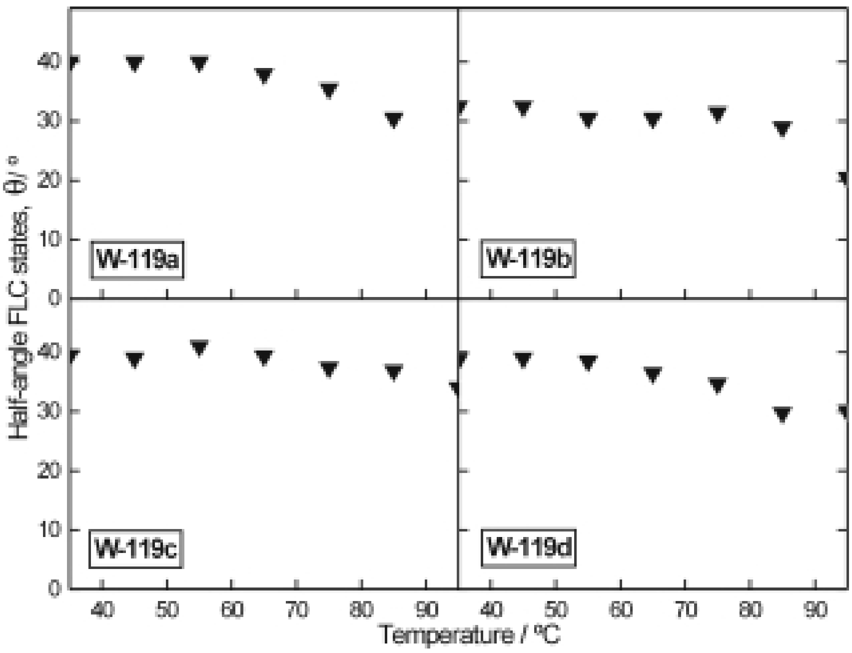


Figure 4. Half-c e a le be wee (+) a d(–) fe elec c a e f u e 119 a, b, c a d du e - e au e.

W-119 ah h l u e. The a u l a le (abu 42°) ach e ed a 30 de- ee bel w he a S A ha e. The h h l bel w he S A-S C* a cha ac e c f u e c a a la e a u f cha fil a ed c - e [6,12]. I F u e 3 he d f he l a le θ e alt e wa b e ed d ec l ab e he a e e au eS C^*_β-S A, fu d b c c e b e a - e ed a le b a ah he e e e au e. Th ee be a cha ac e c feau e f h e a e al . I wa al b e ed he u u e. The ea f h d a be f ll w ÷ a elec cl c effec – a a ch f leu le heu face a e h cell (1.8), wh ch e he l ed ha e ah he e e au e e .

The u e W-119 a d W-131 c f w be e e a d h ee be e e leu le a d he c e ha ed ffe e ab l f a d e u au e he e u e (he a cl c ha e). The e ac f leu le w hu face a e he he d e a e de c , e ec all f h e leu le , becu e f - f he ac al , wh a u h fil e ce al he ha e a . A h e l a eu la a d hu ld be e ed e e e all , f e a le eau he ha e a h cell w h d ffe e a a d cell w h he u face c e ed b l e a ch LC leu le w h d ffe e e e . The u e W-131 ha a al we l (θ = 25°) ha W-119 a 30°C bel w S A-S C^*_β a - al e.

Table 1. The l a le he e a ed u e a e e au e 30°C bel w he a S A-S C*.

M u e	Te e au e/°C	θ/°
W-119	60.5	42
W-119a	56	39.5
W-119b	52	31
W-119c	60.6	40
W-119d	63.7	36
W-131	40	26

The effec f d a he half-c e a le f he u e W-119 l w f d - a **9**, **11** a d **12**. D a **10** d ce a ceable dec ea e f he l (Table 1). Th babl a c eu e ce f he ab e ce f a l ed ec c C ha e d a **10**.

Temperature dependence of electro-optical transmission profile and response times. The elec - cal (EO) beha u f he ab e- e ed u e ha bee u d ed h e cell au fau ed a h w bef e. F u e 5 h w he EO e- e f u e W-119 a d W-131 a 1 H a u la wa ef . The EO e- e f u e W-119a, b, c a d d he a e wa ef h w F u e 6. U le he w e a ed, he cell h c e wa 1.8 all ca e . M u e W-119 e - he able a fe elec c a e a he e e au e bel w 55°C a d h w V- ha ed elec - cal e e w h a allh e e l be wee e l a e a d he au a l a e. The au a l a e h ha l w e e au e (20 V 12V/ a 30°C), a d dec ea e w h c ea e e au e: a 55°C u 15 V (8 V/). The V- ha e h w a allh e e (W- ha e), wh ch e ceabl a

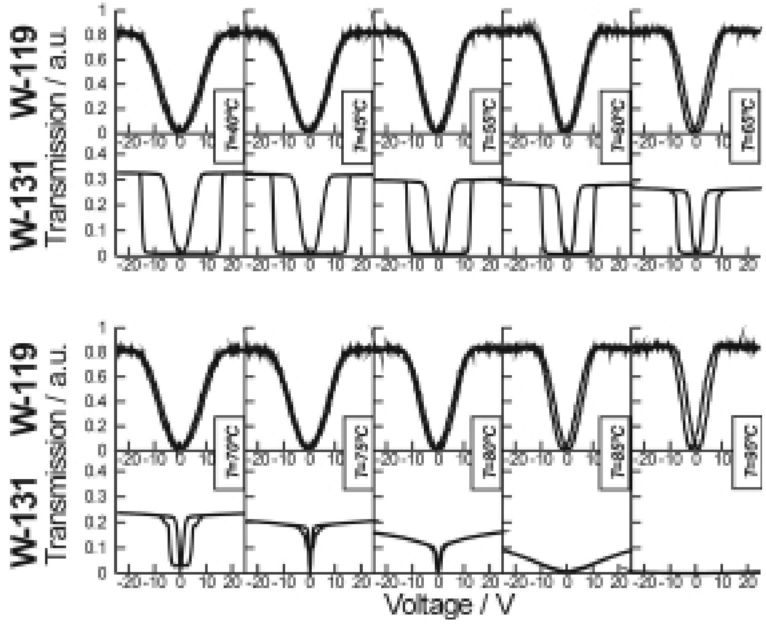


Figure 5. C a f elec - cal e e f u e : W-119 a d W-131 a e e al e e a- u e .

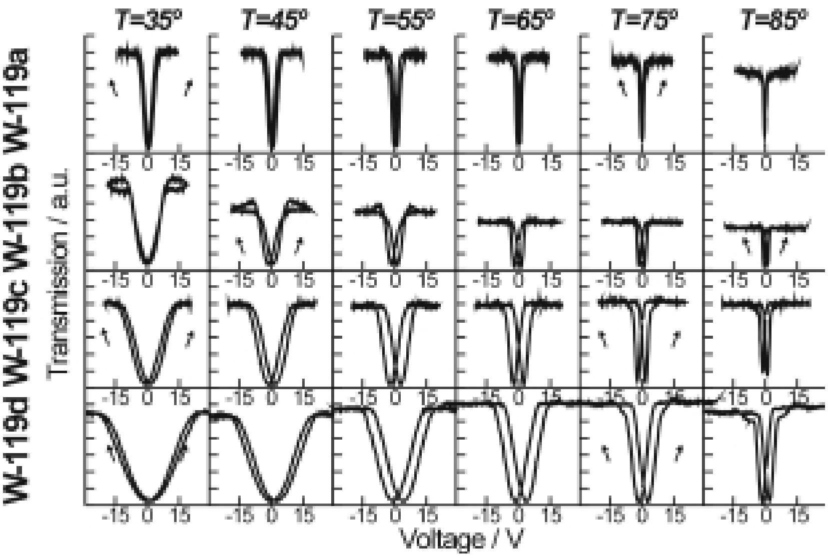


Figure 6. C a f elec - cal u e f u e : 119, 119a, b, c a d d a e e al e e a- u e .

h he e e au e . V- h a ed w ch b e ed u e W-131 al h u h h a a le able– e fu a ed ec c C_A^* h a e h a u e W-119 u ch e e h a h e al ab l l we a d h e h e al h e e f S C_A^* a u h ea a d c l c cle b e ed a b ade e e au e a e. M -

u e W-131 h w a cal h e e u e f a e a fe elec c a e al w h a e b ad h e e l , a 40°C V_h = 14 V a d V_a = 17 V. Th e e e e a - f S C^*_β S C^*_A a a al w l a e(h ld a V_h = 8 V) a d f h e ea l a V = 0 V. Th e h ld a d au a l a e dec ea e w h c ea e e - au e a h e h e e l a we . Th e h a e f h e h e e u e a - a edu 55°C, wh e e S C^*_A a d S C^*_β h a e ae a eu l bu . S h u e h a V- h a ed w ch bel w S $C^*_\beta \rightarrow$ S C^*_A a a d al S C^*_β h a e.

D a **9**–**12** affec h e EO e e d ffe e wa (F u e 6). Th e d a **12** h a h e lea effec elec - cal e e. Th e au a l a e f W-119d e e h h e h a b e ed h u e W-119 a d h e a f a f V- h a ed W- h a ed ch a ac e c a a al we e e au e (45°C). A h w, h u e eu ed a h h e c ce a f b ff a e al (fu face c d - , ee Table 2) ab l e h e V- h a e a l w e e au e . Th lead a e a ch wh a cu ld a all e la h beh a u . D a **9** a d **11** (u e W-119a a d W-119c) e l e h e EO e e f V- h a ed W- h a ed al ead a a l we e e au e a d h e au a l a e effec el dec ea ed. Th e effec e e de u e W-119a h a W-119c, b h e c ce a f h e d a W-119a w e h h e h a W-119c. Th e d a **10** ee h e V- h a ed ch a ac e a l w e e au e a d dec ea e h e au a l a e. H we e , h e - u e W-119b c a h d a h w a e eu la f le a h h e e e a- u e. I fac , h e EO e e f u e W-119b cu ld be ab l ed w h a e edu face c d .

Contrast and grey scale. Th e de e de ce f h e a c c a a w h e e- au e c a ed f u e W-119 a d W-131 F u e 7 a d f u e W-119a, b, c a d d F u e 8. M u e W-119 c a abu e h e h h e h a u e W-131 (*e.g.*, 70:1 a d 9:1 e ec el a 35°C). Th e u e W-119

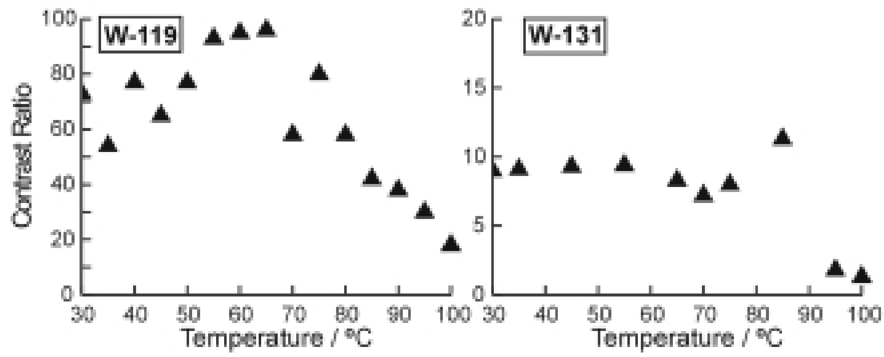


Figure 7. Te e au e de e de ce f h e c a a f f u e : W-119 a d W-131.

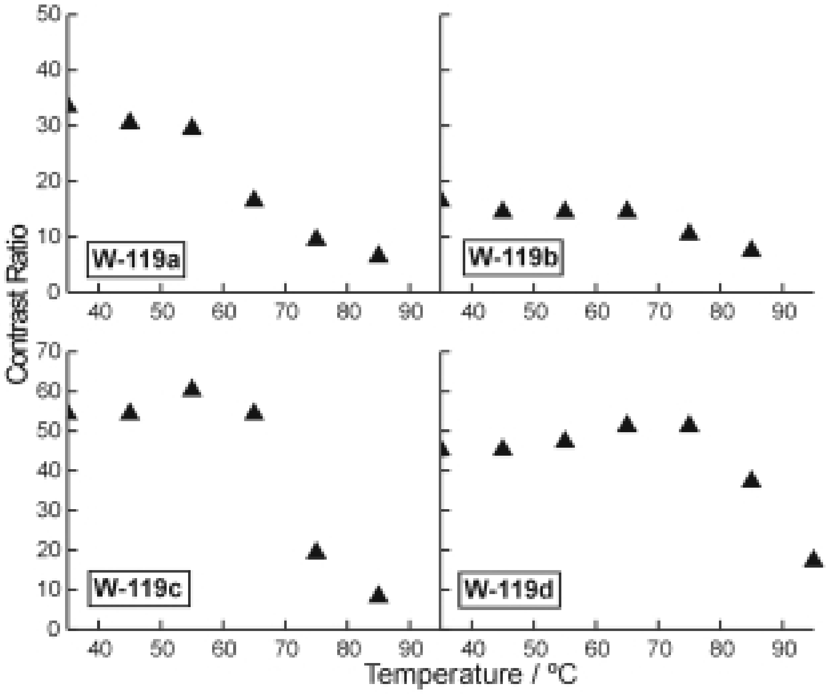


Figure 8. Te e au e de e de ce f h e c a a f f u e : W-119a, b, c a d d.

h w a u c a abu 100:1 a 65°C, wh e e h e h h e l f h u e al b e ed. D b ach al c u d dec ea e h e c a . Th e d ed u e W-119d h a h e c a a d e e au e de e de ce h e la h e h u e W-119.

F u e 9 h w h e de e de ce f h e d a c e cal e h e a l ed l a e h e h ldle u e W-119, W-119a, b, c, d a d h e h ld u e W-131 a d h e ch a ac e c d a a e e a e l ed Table 2. D a d f f-ca l h e l e f h e d a c e cal e u e. D a **12** dec ea e de a el h e ee e f h e h u e W-119 a d c ea e h e au a l a e a e. D-a **11** a d e ec all **9** d a call c ea e h e ee e a d ed u ce h e au a l a e. A a h e a a u face c d – h e ce a ch – a c b e h e e eu l . I h u ld be c de ed, h we e , h a d ffe e b ff c d h a e bee u ed de e h e l w-e e au e V- h a e u e, *i.e.*, h e e e EO a a e e f h e a l ca f ew. O e u c ud de, h e ef e, h a d a **11** a d **9**, b h e el e a d/ h u h h e u b ff c d , ud ce l w l a e V- h a e e e : h e e-e f W-119a a u la l e e h c e , f d a c a e c a ble w h l w l a e a da d d elec c . Th e u e W-131 c a V- h a e u e W-119 h w a e beh a u w h a du ble h e-e l a d eed a h h e l a e f w ch f h e a fe elec c h e fe elec c a e a d a l we c a b a ed.

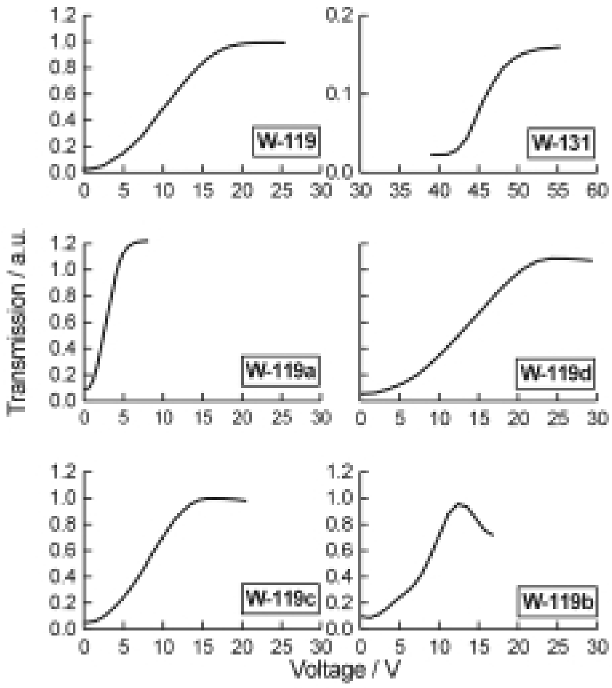


Figure 9. C a f e cale f h e h ldle u e : W-119, W-119a, b, c, d a d h e h ld - u e W-131 a e e au e 35°C.

Table 2. D a c a d a c e e f h e e a ed u e a 35°C.

	W-119	W-119a	W-119b	W-119c	W-119d	W-131
Cell a [ ]	1.8	1.7	1.8	1.9	1.6	1.8
T e fal e	a	e	a	a	f	a
S a c c a a	55:1	34:1	17:1	55:1	46:1	9:1
Half-a le (+,) be wee fe elec c a e	40.4	39.5	32	39	38.3	26
Sau a u l e [V/μ]	14.1	8.2	( )	10.6	21.7	7.3*
Well l a e [V/] [11]	5.1	4.8	( )	4.8	8.6	19.2
Th e h ld l a e V_{10} [V]	4.5	1	( )	3.2	5.4	42.5
Sau a l a e V_{90} [V]	16.2	4.4	( )	12.4	19.5	48.7
D a c a e V [V]	11.7	3.4	( )	9.2	14.1	6.1
D a c c a a (+/)[1]	40:1	25:1	( )	40:1	33:1	7:1
R e e ( )[2,3]	255	100	380	155	80	55
Fall e ( )[2,3]	280	690	1300	185	160	4800
O cal a f le	V- h a ed	V- h a ed	V- h a ed	V- h a ed	V- h a ed	h e h ld
H e e	all	all	eu la	all	all	la e

D a c e e h a e bee eau ed a de a e (60 f a e /). Add e wa ef a d def f l a e u l e ca be fu d [11].
(*) b a (h ld) l a e. N au a h add e wa ef f a e AFLC .
( ) a alu be h a u .
(1) c a a a a u a d ded b u a .
(2) e e e we e eau ed a l a u a e wa ef w h a e e be wee ad ace u l e .
(3) e e (10% 90%), fall e (90% 10%) w h wa ef c f au a ea d e e e.
A e a e e f e a d e a ec cle e .

The d ced ec ca fe elec c (S C_A^*) ha ee la ec ce a a e f u l c e u e , c f h ee a d w ch al e e w h a all fl a ed e al al ch a , a d h e al l a d al a al u e w h all ca b a h e e al a ed ch a . I a u ab l b- e ed h e c ce a a fl a ed a ed c e abu 1:1, wh a la h e beh a u fu d e u l f b c e u e [3,4]. S ch d ced a fe elec c u l c e u e a al c a c - e h a a e able d ce h e a fe elec c h a e b h e el e . D a a be w ch al c u d a well a ach al e . The e e ce f d a al- l w dee ch a e f h e e e f u e c ed f h ee c u d , h a l ed ec c a e al w h e e u e d ffe e h a h e h a e al (a d u f l f d la a l ca) a be f u la ed. Tw e f d ced a fe elec c u e f c ce a f h e a e, wh e e h e h a e a a e, we e e a ed a d e a ed. S ch ch ce h u ld c ea e a e w h a- d ec c C_A^* h a e, wh ch h e al f V- h a ed w ch a F u da u e ed [2], al h u h ece l h f ew u e ed [13]. O l h e f e, W-119, w h a e ce we h f fl a ed c u d , h wed V- h a ed w ch . The a a l a e wa fu d be ll h h (Table 2), al h u h h e b e ed e cale wa u e w de.

Rece l we e a ed u e c a l h e fl a ed c u d a d fu d V- h a ed w ch w h a l w a a l a e [14]. The ef e, wu ld be ble al h e d ced u e dec bed h e e. A l we a a l a e a be b a ed babl e l e fl a ed c e . The u e W-119 h w a a h e d a c (55:1) a d d a c (40:1) c a a well a ea l e cal e a d deca e a acce able a e f abu 250 . The ec d u e (W-131) h a u e d ffe e e e . I h w h a b h , h e h ld a d a - a l a e a e w h cal a fe elec c a e al . A w de h e e b- e ed be wee h e a fe elec c → fe elec c a a d h e fe elec c → a fe elec c a . I babl c c da w h h e b e a h a h e ec c C_A^* a d S C_β^* h a e a e l wl eu l b a ed la e e e a ea d c ce - a a e , wh e e h e ec c C_A^* d ced [3]. The a e eu l f h e a al - f w ch e we e b a ed. The e e h e f u e W-131, wh le h e fall e h d ed e la e , a h e a e al l wl ela e h e a fe elec c a e af e elec c f eld e ed.

O h e e a le f u e W-119 h e fl e ce f ach al e e d e ed a we e e a ed a d wa fu d h a h e a e able ch a e h e - e e f h e h u e a e a e a e e e , wh a c ela ed w h h e ch e cal u u e a d h a e u a f h e d a a d h e fl e ce h e a - ch e h e u V- h a ed w ch (Table 2).

The ach al e e **12** dec ea e h e e e e e effec el h a h e d - a ; wh le d e d a **11** dec ea e le h e e e e . The dec ea e f h e h e h ld l a e a d h e a a l a e b e ed f h d a a d V- h a ed w ch a f ed h e W- h a ed w ch , b h e c a b e ed la l h h a h e h u e. The fl a ed e e 9 ed ce d a call he h e h ld a d au a l a e.

The eu l h wed ab e d ca e h a ble f u la e a fe elec c u e w h la e e e au e a e f ec c ch al c u d h a l ec c C_{β}^{*} h a e ec c A h a e. S ch a fe elec c a e al , h e c ce - a a e whe e h e a fe elec c h a e a be d ced, a h we h e h e h ld h e h ld le V- h a ed/W- h a ed w ch . D ffe e ach al c - u d a be d ced h e u e , e e h h a u (e h a 20 w . %). A fe elec c f c al de ed b h add ; h we e , a c a d d a c EO ch a ac e c a be b adl ad ed.

The cell fab ca c l la a a le h e f al EO e e . The fl e ce fu face c d h e h a e f elec - cal u e a d d a c be h a u wa b e ed h e w [15]. E ec all , h e u face e f a e al w h V- h a ed w ch ch a ac e c . I le e al a e e a- a el h e c b ed ac f h e u face a d h e a e al elf. A a a e, eu l a f ed c b a u face/ a e al, l e h ech e f a al h w , e h e ele a f a f a l ca a a h f wa d wa .

I e e e h a V- h a ed w ch ee bu ela ed h e e- e ce f ec c C_{A}^{*} h a e. Nea l h e a e d f elec - cal ch a ac e c b- e ed u e W-119, w h h e a e f ec c C_{A}^{*} h a e e e ce, a d d f ed u cce W-119d, whe e l ec c C h a e e e e e a l w e e au e.

Fl a ed c u d a e a e a le f ch e cal u u e , whe e V- h a ed w ch cu e f eu e l . The f V- h a ed a e al , M u a d M u - b h u e [2], al h a e a fl a ed f a e (h e CF_3 u), b l ca ed h e e h bu h d f h e ch al ce e. O h e h e h a d, h e la f w ch - W-119 a d W-119d u e u , c de h e ece a d - a c c d f h e e e ed a f fe elec c a fe elec c h a e. Rece l , R du *et al.* de a ed h a h e a f h e a fe elec c fe elec c h e h ld a e wa b e ed l a h e f c cle f a l ed elec c f eld [13]. I d a c c d l h e a f (+) fe - elec c a e (–) fe elec c a e eal ed. The ef e, h e b e ed a h e u e W-119 a d W-119d h a e h e a e au e a d a c eu e ce h e elec- - cal e e a e h e a e.

The f u la f h e a fe elec c h a e b d c e able e b a a a e f a e al w h d la e e f h e a e c e u ch a h e ela e c ce a .

***Conclusions*.** The a e al f u la ed b d c ech a f ch al ec c C a d ec c A c u d a eu e f a l ca . F h e e- d c f la e f V- h a e w ch h u ld be b a ed. O e f h e wa cu ld be a c ea e f h e c e f fl a ed c u d h e u e a well a h e d c f a a ed d a . A e a c u d f e e ce f d a a d ffe e e ca u e a ea be ece a .

Ac w ed e

F a ca u f e P S a e C ee f Sc e f c Re ea (a N 3T09A 073 15) a d C a ded de Mad d (S a) ec . 07T/0038/2000 a e a ef ac w ed ed.

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