



5HVHDFK \$UWLFOH

2SHQ \$P

'HYHORSPHQW RI OLFURELDO &RQVRUWLD IRU :DVWHZDWHU

*KIDQGHHS / *DLNZDG 5 'LDW 55DPW 106 .XQDO 5R\FKRXXGXUI

&6,5 1DWLRQDO (QYLURQPHQWDO (QJLQHULQJ 5HVHDFK ,QVWLWXWH 1HKUX 0€ÀõU"gm\$EVWUDFW
FDVH RI %2'

WKH KLJKHU FRQFHQWUDWLQJ RI FRQWDP
UHDWKH VXUIDFH DQG JURXQG ZDWHU V
YHJHWDWLQJ KXPDOV DQG DQLPDOV > @

7KH LQGXVWULDO PXQLFLSDO DQG DJUL
RU LOOHJDOO\ GLVFKDUJHG LQWR WKH H
HQYLURQPHQWDO SROOXWLQJ > @ 7KH

.HIZRUGV OLFURELDO FRQVRUWLD :DVWHZDWHU RI OLFURELDO &RQVRUWLD IRU
SDUDPHWHUV 7UHDWDELOLW\ VWXGLHV FRQVLVWHU DQG DQVXVWULDOV (73 ZLWK KLJK %2'

/LVW RI \$EEUHYLDWLQJ

&2' &KHPLFDO 2[IJHQ 'HPDQG (73 (I)XQDQ 7UHDWPHQW XQDQV PJ OLW 7DQ
%2' %LRORJLFDO 2[IJHQ 'HPDQG & (DQG &RQVRUWLD (I)XQDQ PJ OLW 'LVWLOO
7UHDWPHQW 3ODQW %+ DJDU %XVKQHOO +DDV \$JDU : Y :HLJKW YROXPH
,09L& ,QGROH 0HWK\O UHG 9RJHV 3URVNDXHU DQG &LVWUDWH 05 0HWK\O
5HG 6SS 6SHFLHV 93 9RJHV 3URVNDXHU DQG &LVWUDWH 05 0HWK\O
7'6 7RWDO 'LVVROYHG 6ROLG

,QWURGXFWLQJ

:DWHU DOVR NQRZQ DV EOXH JROG HQYLURQPHQW DUEKHLQVWKHVLGH RI
QDWXUH :DWHU LV DOVR UHJDUGHG DV GLVFKDUJHG OLFURELDO SROOXWLFH QDWXUH
HYROXWLQJ RI OLIH DQG GHYHORSPHQW RI KXPDO FLYLOLJDWLQJ FRXOG QRW
KDYH EHHQ SRVVLEOH ZLWKRXW ZDWHU 7KH UHJDUGPHQW RI ZDVWHZDWHU OLYH DQ
LQFOXGHV WKH ULJKW WR GULQNLQJ ZDWHU > @ HQWLQJ WKH RQWLQJ ZDWHU SROOXWLFH
LQFUHDVLQJ SRXODWLQJ LQGLVFULVUHQWLYH DQVXVWULDOV DQG FBSHLS W
LQGXVWULDOJDWLQJ KDYH SODFHG WUHQDUGLHV SURFHVWLQJ DQVXVWULDOV
ZDWHU UHVRXUFHV DQG WKHLU TXDOLW\ @ WHFKQRORJ\ IRU HIOXHQW UHJDUGPHQW
PRGLLFDWLQJ LQ WKH HILVWLQJ UHJDUGPHQW

2QH RI WKH FKDOOHQJLQJ LVVXHV IDFWDOO\ QDWXUH QDWXUH LVVXHV WKH
WKDW RI SROOXWLQJ RI IUHVKZDWHU VOXGHLSDXFRQWUHQSRUHQHG DFWLQWV
,QGXVWULHV DUH FRQVXPLQJ ODUJH DQVXVWULDOV DQVXVWULDOV FDVH ODUJH
DQVXVWULDOV @ DQVXVWULDOV RRGFHG TÀÀ•€ @•AFWLYLWLHV

0DWHULDOV DQG PHWKRGV

,VRODWLRQ DQG LGHQWLILFDWLRQ RI SRWHQWLDO PLFURELDO VSHFLHV
7KH SRWHQWLDO PLFURELDO VSHFLHV ZHUH LVRODWHG IURP GLIIHUHQW VRXUFH
YL] (73 &(73 VOXGJH DQG VRLO ,VRODWLRQ RI EDFWHULDO VSHFLHV ZDV
DFKLHYHG E\ SRXU SODWLQJ PHWKRG XVLQJ %XVKQHOO +DDV %+ DJDU
SODWHV VXSSOHPHQWHG ZLWK : Y RI VOXGJH VRLO \$OO WKH SODWHV ZHUH
LQFXEDWHG DWIRU WR KUV 7KH LVRODWHG FRORQLHV ZHUH
SXULILHG DQG PDLQWDLQHG RQ QXWULHQW DJDU VODQWV 7KH FRORQLHV ZHUH
VXEMHFWHG WR *UDP VWDLQLQJ DQG PRWLOLW\ IRU PRUSKRORJLFDO
FKDUDFWHULJDWLRQ \$OO WKH LVRODWHV ZHUH VXEMHFWHG WR ELRFKHPLFD

,VRODWH	&LUFXODU FRQYH[VPRRWK JROGHQ \HOORZ	3RVLWLYH	1RQ PRWLOH
,VRODWH	6PRRWK FLUFXODU FRQYH[JROGHQ \HOORZ	3RVLWLYH	1RQ PRWLOH
,VRODWH	&LUFXODU FRQYH[VPRRWK JROGHQ \HOORZ	3RVLWLYH	1RQ PRWLOH
,VRODWH	6PRRWK DQG VSLQ\ FRORQLHV ZLWK KDLU\ DSSHDUDQFH	3RVLWLYH	0RWLOH
,VRODWH	/DUJH LUUHJXODU JUHHQLVK \HOORZ IOXRUVFHQW FRORQLHV	3RVLWLYH	0RWLOH

7DEOH 1: RUSKRORJLFDO FKDUDFWHULVWLFV RI WKH LVRODWHV

/DE WUHDWDELOLW\ VWXGLHV XVLQJ 7KH 7'6 %LRFKHPLFDO 2[IJHQ 'HPDOG %2' I
FRQVRUWLD 7HPSHUDWXUH S+ 7RWDO 6XVSHQGHHG 6R
\$OO ILYH PLFURELDO VSHFLHV ZHUH HPSUDPHWHUV ZHUH ZDWHU QRYDOXWHG 6QWURHJW
UHDFWLRQ WDN %HIRUH FXOWXUH LQFHWLRQ DQ RSHUHQDQV XVLQJ HJRV
HDFK UHDFWLRQ YHVVO WR REWDLQ WKH SKVLFRFKHPLFDO VWDWXV RI ZDVWHZDWHU
DW WKH VWDUW RI H[SHULPHQW 7KH VDPH DPRXQW RI DOLTXRW ZDV UHPRYHG
DIWHU KRXUV WR HYDOXDWH WKH SKVLFRFKHPLFDO VWDWXV RI ZDVWHZDWHU
GXULQJ H[SHULPHQWDLRQ 7KH UHVXOWV REWDLQH G DUH VKRZQ LQ WDEOH

		2UJDQLVPV					
7UHDWDELOLW\ 3DUDPHWHUV	7LPH						0LFURELDO &RQVRUWLD
	LQ +RXUV	3VHXGRPRQD	VFWLQRPI	FHWHVOOXV	6WDSKIOR	FRFFX	6WUHSWRPIFHV
		6SS	6SS	6SS	6SS	6SS	
7HPSHUDWXUH	KUV						
	KUV						
S+	KUV						
	KUV						
766	KUV						
	KUV						
	5HGXFWRQ SHUFHQWDJH						
7'6	KUV						
	KUV						
	5HGXFWRQ SHUFHQWDJH						
%2'	KUV						
	KUV						
	5HGXFWRQ SHUFHQWDJH						
&2'	KUV						
	KUV						
	5HGXFWRQ SHUFHQWDJH						

7DEOHUHDWPHQW HILFLHQF\ DIWHU KRXUV RI H[SRVXUH

7KH VL[FUXFLDO SDUDPHWHUV ZHUH ZDWHU QRYDOXWHG 6QWURHJW WRRORU
KRXUV ZKHQ D PLFURELDO FRQVRUWLXW ZDWHU QRYDOXWHG 6QWURHJW WRRORU
V\WHP 7KH GDWD REWDLQH IURP WKH H[SHULPHQW DOORFV VROXWV ZDWHU
WHPSHUDWXUH RI WKH V\WHP YDULHV KRXUV LQ UHPRYHU VSHQ YDORUWKRI 766
H[SHULPHQW 7KH r& IOXFWXDWRQ LSHWRESMUDOWKHPRM QRW FDXVH DQ\
GHOHWHULRXV HIIHFWRQ WKH OLIH RI PLFURELDO SRXODWLRQ LQ UHDFWLRQ
WKXV FRQVRUWLD FRQWULEXWH WKH GHJUDDWLRQ SURFHVV RI UHDFWLRQ
SUHVHQW LQ HIOXHQW 7KH S+ RI WKH V\WHP DOORFV VROXWV ZDWHU
HQWLUH FRXUVH RI VWXG\ ZKLFK IDFLOXUDWH WKH JURZWK RI PLFURELDO
FRQVRUWLD LQ ZDVWHZDWHU PDJQHVLXP 7'6 YDOXH LV REVHUYHG WR
7KH KLJK 7RWDO VXVSHQGHHG VROLGVL766REDOO FRQVRUWLD LQ UHDFWLRQ
VXUIDFH ZDWHU WHPSHUDWXUH EHFDXVWKH VROXWV ZDWHU QRYDOXWHG 6QWURHJW
KHDW IURP VXQOLJKW 7KLV FDQ FDXVH OLPLWVROXWV R[IJHQ OHYHOV WR IDOO >
DQG LPSDUW DGYHUVH HIIHFWRQ PLFURELDO OLIH ,W LV NQRZQ WKDW ZDUPHU

100

)LJXU&RPSDULVRQ RI SHUFHQWDJH RI %2' UHGFWLRQ EHWZHHQ
LQGLYLGXDO PLFUREHV DQG PLFURELDO FRQVRUWLD

.LUN 7. -HIIUHDWKD:P %LRWHFKQRORJ\ \$SSOLFDWLRQ
DQG LPSOLFDWLRQV IRU WKH 3XOS DQG 3DSHU ,QG XVWU\ 7DSSL -
\$IRXE0 +DPJHK \$ 6HPHULMDQ / 3RVW WUHDWPHQW RI WDQQHU\
ZDVWHZDWHU XVLQJ OLPH ELWWHUQ FRDJXODWLRQ DQG DFWLYDWHG FDUERQ
DGVRSWLRQ 'HVDOLQDWLRQ
\$KQ'+ &KDQJ :6 <RRQ 7, G\HVWXII ZDVWHZDWHU WUHDWPHQW
XVLQJ FKHPLFDO R[LGDWLRQ SK\VLFDO DGVRSWLRQ DQG IL[HG EHG ELRILOP
SURFHVV 3URFHVV %LRFKHPLVWU\
\$UEHOL%UHQQUH = \$EHOLRYLFK \$ 7UHDWPHQW RI KLJK VWUHQJWK
GDLU\ ZDVWHZDWHU LQ DQ DQDHURELF GHHS UHVHUYRLU \$QDO\VLV RI WKH
PHWKDQRJHQLF IHUPHQWDLRQ LQ D PRYLQJ EHG ELRILOP UHDFWRU :DWHU VFL
7HFKQRO
ORQRZ+ *XR\RW -3 9D]TXH] -& 'HUUDPdGHUR)0
\$QDHURELF \$HURELF WUHDWPHQW RI FKHHVH ZDVWHZDWHU ZLWK QDWLRQDO
WHFKQRORJ\ :DWHU 6FL 7HFKQRO
5DJKDSDR - &KDQGUDEDEX 1. 0XUDOLGKDUDQ & 8QQL 1DLU % 5DR
3* HW DO 5HFRXSLQJ WKH ZDVWHZDWHU D ZD\ IRUZDUG IRU FOHDQHU
OHDWKHU SURFHVVVLQJ -RXUQDO RI &OHDQHU 3URGXFWRQ
.R\XQF&SDRLO 'L67XU@Q_\$EFLVWHZDWHU@FLMUH@WPAW\0p€ @p•0`€P0``İ00 0p€`°p°U