



5HVHDFK \$UWLFOH

2SHQ \$F

%DFLOOXV FHUHXV 0HGLDWHG™ FDSURODFWDP
:DWHU 7UHDWPHQW RI 1\ORQ 3URGXFWLRQ 3

0HKWD 6. 3DQFKXOV DOD %1 DQG 6DQH 6\$
'HSDUWPHQW RI %LRWHFKQRORJ\ 5HVHDFK DQG 'HYHORSPHQW &HQWUH *XMDUDW 6WDWH)HUWLOL]HUV
&RUUHVSRODQV DQG 6\$ 'HSDUWPHQW RI %LRWHFKQRORJ\ 5HVHDFK DQG 'HYHORSPHQW FHQWUH *6) &
(PDVVDQH#JVIFOWG FRP

%DFLOOXV™ FDSURODFWDP GHJUDGDWLRQ &KHPLFDO
2[\JHQ 'HPDQG &2' UHGXFWRQ 1\ORQ ZDVWH ZDWHU /& 06 06

,QWURGXFWLRQ

™ FDSURODFWDP & + 12 LV D [HQRELRWLF RUJDQLF FRPSRXQG ,W LV
DQ H[FOXVLYH UDZ PDWHULDO IRU 1\ORQ SRO\PHU ZKLFK LV SURGXFHG E\
K\GURO\WLF SRO\PHU]DWLRQ RI

\$GGLWLRQDO\ LQ SUHVHQW VFHQDULR
RMSHFLILF FDSURODFWDP WROHUDQW PLF
FDSURODFWDP FRPSRVLWLRQ LV H[WUHP
ZDVWHV ,W SURYLGHV EHWWHU VSHFLIL
UHGXFWRQ 6HYHUDO UHSRUWV KDYH VK
ZDWHU XWFDOSURDFWDP WROHUDWLQJ ED
FDOFRDFHWLFXV LVRODWHG EHFDSMRDHF
FDSURODFWDP > @WRXMDUDW 6WDWH O™DQG 6DQH 6\$
)HUWLOL]HUV DQG &KHPLFDOV /WG PH&LXP DQGRGDZD WKLVDSDUWDP IRUV
PDQXIDFWXUHU RI 1\ORQ LQ ,QGLD V\QWUWUFDQ PLQXIDFLXUDDO\ R6DQXWK
1\ORQ KHDYL\ FDSURODFWDP DV DQ DQV\RUHGLDWHOD:VWDSRQDQDFWDEJZKLF
ZDWHU RI WKLVDSDUWDPDQV\RUHGLDWHOD:VWDSRQDQDFWDEJZKLF
FRQVWLWXHQW > @ ZKLFK FDXVHV VLJQLWDESRDQVLRQDWRHVKHQRORJ
DQG H[HUV WR[LFLW\ WR OLYLQJ EHFDSMRDHF VSHFHUWKLVDQWFKRQHFVFX
WUHDWPHQW SULRU WR LWV GLVFKDUFDSDUWDPHQRORJH 7KHUO LVK
VHSDUDWH WUHDWPHQW SODQW 73 ,, QMFUHFZKURQSHDQZRQKHQWUHDWLRQL
RI HIOXHQW IURP 1\ORQ SODQW \$FFRUGLQJ WR WKH HQYLURQPHQWDO QRUPV
VHW E\ WKH *RYHUQPHQW RI ,QGLD FKHPLFDOV GHFDGIR&2 OHYHO LVROD
RI ILQDO ZDVWH ZDWHU VKRXOG EH FDSURODFWDP GHFDGIR&2 EDFWULDIUR
WKLVDSDUWDP 5RQV\RUHGLDWHOD:VWDSRQDQDFWDEJZKLF
UHGXFH &2' RI WKLVDSDUWDPHQRORJH 7KHUO LVK
73 ,, 7KH REMHWLYH RI WKLVDSDUWDPHQRORJH DGGIWRQDQVWZRU
ZDWHU DV SHU *RYW QRUPV WKURXJK EDFWULDIODZDWHUHQGLW
%LRUHPHGLDWLRQ XVLQJ VHOHFWHG PLFURRUJDQLV SURYLGH D JRRG
RSSRUWXQLW\ EHFDXVH LW LV HQYLURQPHQWDO\ IULHQGO\ DQG FRVW HIIHFWL
> @ 7KLV ZLOO UHPDUNDEO\ UHGXFH WKH HQYLURQDQW ZDWHU VKRQ
SXUSRVH DQG H[SHQGLWXUH LQ EX\LQJ H[WUD ZDWHU

\$SSOLFDFWLRQ RI VSHFLILF PLFURRUJDQLV IRU ELRORJLFDO WUHDWPHQW RI
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DQ DOWHUQDWLYH WR WKH H[LVWLQJ ZDWHUHQGLDWHOD:VWDSRQDQDFWDEJZKLF
.XONDUQL DQG .DQHNDU KDYH GHPRQVUDWHG DSSOLFDELOLW\ RI
3VHXGRPRQDV DHUXJLQRVD IRU GHJUDGDWLRQ RI FDSURODFWDP IURP
1\ORQ HIOXHQW > @

&ROOHFWLRQ RI VDPSOHV

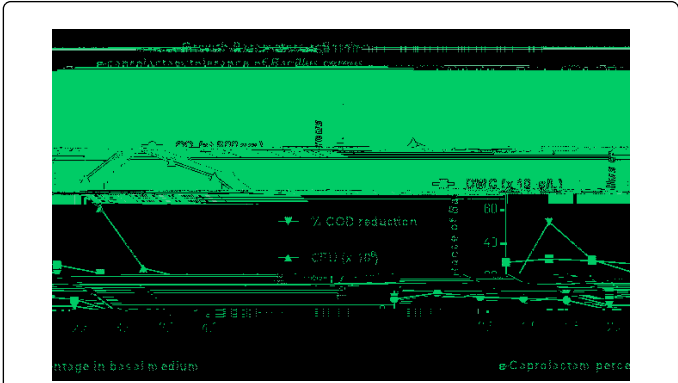
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&KDQQHO /LPLWHG DQG :DVWH ZDWHU ZDWHU RI *6)& IURP YDULRXV

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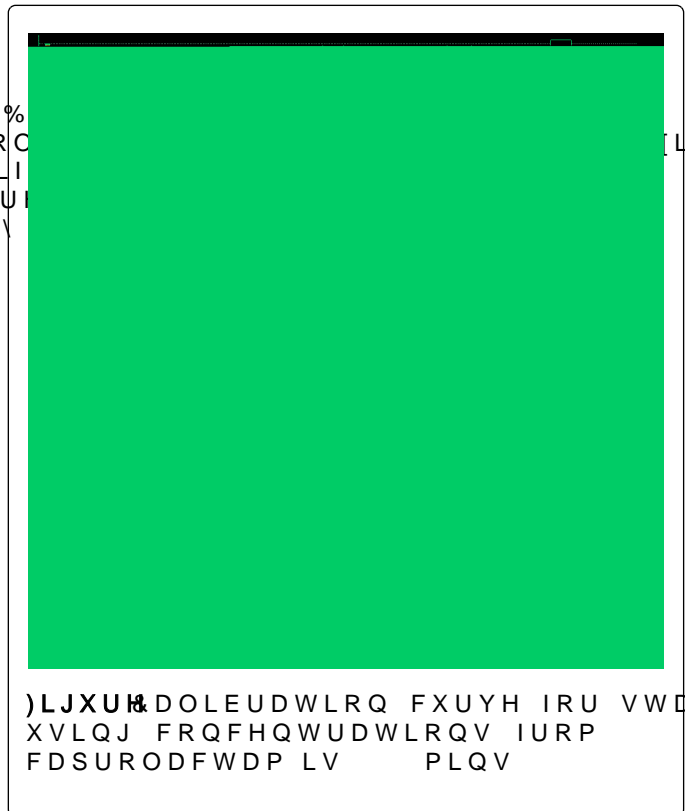
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ZDWHU IRUWLILHG ZLWK VDOWV RI EDVDO PFC6XBDQDO@LWKH SXUSRVH RI XVLQJ
 XQIRUWLILHG 1\ORQ :DVWH ZDWHU IRU WKLV ZRUN ZDV WR UHGXFH WKH :DVWH
 ZDWHU WUHDWPHQW FRVW DW WKH WLPH RI WKLV SXUSRVH FDSURODFWDP REWDLQ
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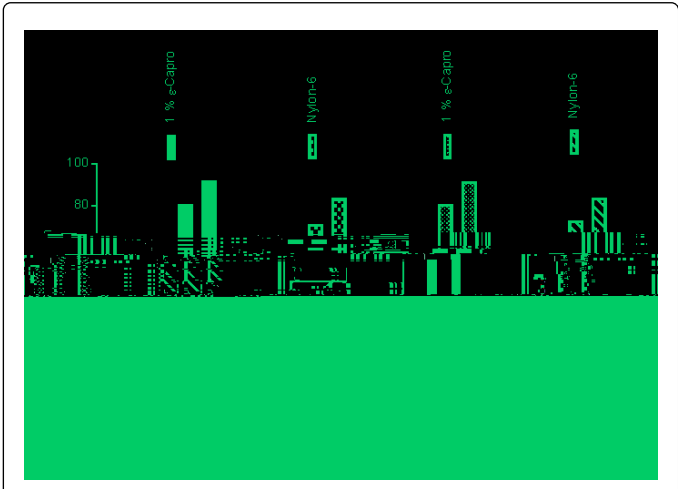


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 FDSURODFWDP IRUWLILHG PHGLXP 7RC
 DQG YDULDEOH PFC6XBDQDO@LWKH RI
 [D[LV 3DUDPHWHUV PRQLWRUHG ZHUH
 SDUDPHWHUV OLNH 2' DW QP GUV
 DQG FRORQ\ IRUPLQJ XQLWV FIX

FRQFHQWURV FDSURODFWDP GLVVROYHG LQ
 4 06 VSHFWUXP RI VWDQGDUG JDYH P J YD
 IUDJPHQV)LJXUH \$ \$ SHDN RI J F
 FDSURODFWDP ZDV REWDLQHG LQ SURGXFV
 % 7KH UHWHQWLRQ WLPH 57 RI WKLV S
 WUHDWPHQW VHW , VDPSOH FDSURODFWDP
 FRQWHQW ZKHUHV LQ VHW FDSURODFWDP
 GHJUDGDWLRQ KDV EHHQ REVHUYHG , Q WK
 FDSURODFWDP FRQWHQW RI WKH VDP
 &2' UHGXFWRQ YDOXH



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 XVLQJ FRQFHQWURV IURP QJ
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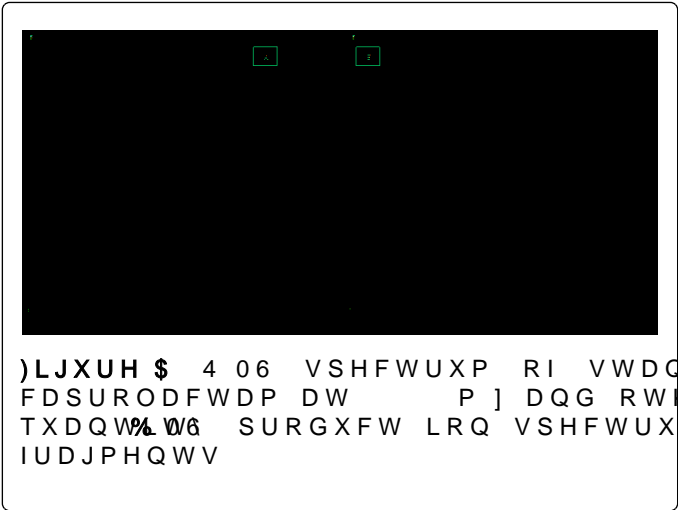


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 UHGXFWRQ ZDV PHDVXUHG E\ RSHQ
 DQGFDSURODFWDP GHJUDGDWLRQ ZDV

&2' UHGXFWRQ DQG RI
 UHGXFWRQ FDSURODFWDP
 UHGXFWRQ FDSURODFWDP RI &2' DQGFDSURODFWDP
 UHGXFWRQ FDSURODFWDP RI &2' DQGFDSURODFWDP
 GHJUDGDWLRQ KDV EHHQ DFKLHYHG GXU
 H[SHULPHQWDO VHW , DQG , DSSUR[LP
 FDSURODFWDP FRQFHQWURV KDV EHH
 6DPH H[SHULPHQW VWRZHG RQO\ GHFU

FDSURODFWDP XWLOLJDWLRQ
 *6)& VWUDLQ ZKLFK ZDV LGHQWLILHG DV
 KDV VKRZQ FDSURODFWDP WROHUDQFH
 UHGXFWRQ KDV EHHQ REVHUYHG
 REVHUYDWLRQ FDSURODFWDP XWLOL]LQJ H[SHULPHQW
 SHUIRUPHG FDSURODFWDP IRUWLILHG PHGLXP %DFWHULXP ZDV
 JURZQ RQ EDVDO V\QWKHWLFFDSURODFWDPVQLQJ
 ZHOO DV VWHULOH XQIRUWLILHG 1\ORQ HIIOXHQW

KUV 2' &8 DQG :& J O RI EDFWHU
 VKRZQ FDSURODFWDP WROHUDQFH
 EXW EHVW &2'
 %DVHG RQ WKLV
 FDSURODFWDP XWLOL]LQJ H[SHULPHQW
 FDSURODFWDP IRUWLILHG PHGLXP %DFWHULXP ZDV
 JURZQ RQ EDVDO V\QWKHWLFFDSURODFWDPVQLQJ
 ZHOO DV VWHULOH XQIRUWLILHG 1\ORQ HIIOXHQW



UHSRUWV DQG ZLOO EH H[SHFWHG WR SOD
FDSURODFWDP SROOXWHG 1\ORQ HIOXH
KXJH UHGXFWRQ LQ TXDQWLW\ RI ZDWHU
IRU WKLW SXUSRVH

\$FNQRZOHGJPHQWV

7KH DXWKRU DFNQRZOHGJHV *XMDUDW 6
IRU ILQDQFLDO VXSSRUW :H ZRXOG DOVR
OLVKUD *0 7 5 *6)& DQG 3URI 6DULWD *
RI %LRFKHPLVWU\ 0 6 8 IRU VXSSRUWLQJ

5HIHUUHQFHV

WRESDQFWDQGHUHQWKGVPIDUWKH ([
:DYSURODFWDPDQGPHULFDQ3XEOLF
86\$

%D[11 6KDK \$. %LRRJLFDU WUHDWPH
VROLG ROLJRPFULF ZDVW IURP D Q\ORQ
OLFURELRO %LRWHFKQRO

%D[11 6KDK \$. FDSURODFWDP GHJUDGDWL
IDHFDOLV IRU ELRUHPHGLDWLRQ RI ZDVW Z

)LJXUH \$ 4 06 VSHFWUXP RI VWDQGDUG ZKLFK VKRZV
FDSURODFWDP DW P] DQG RWKHU WRESDQFWDQGHUHQWKGVPIDUWKH ([
TXDQWLW\ SURGXFW LRQ VSHFWUXP RI FDSURODFWDP DQG PHULFDQ 3XEOLF
IUDJPHQWV

'LVFXVVLRQ

\$W *6) FDSURODFWDP LV XVHG DV D PROPHIRU WKH SURGXFWLRQ
RI 1\ORQ ,W LV RIWHQ IRXQG DV QRQUHFWLYH FRPSRQH %D\XORQ % 7DUD
SODQW ZDVW ZDWHU \$V SHU WKH \$XEOLWKGUHSRUWV *WKH & ZOWU OXH DQG
FDSURODFWDP FRQWHQW LQ WKLW ZDVW ZDWHU LV EHWZHHQ SSP
DQG SSP UHVSHFWLYHO\ > @ %\ PHDQV RI WKH SUHVHQW ZRUN ZH
KDYH VXFFHVVIXOO\ UHGXFHG &2' RI 1\ORQ HIOXHQW IURP SSP WR
SSP 7KLV LV D PLOHVWRQH E\ ZKLFK ZH FDQ JUHDWO\ UHGXFH WKH
ZDWHU FRQVXPSWLRQ IRU ZDVW ZDWHU WUHDWPHQW DQG WKLW ZLOO DOVR VD
H[WUD FRVW WR DFKLHYH WKH DFFHSWDEOH &2' YDOXH ,Q DGGLWLRQ WR WKLW
ZLWK LQFUHDVH LQ DHUDWLRQ FRQGLWLRQV RI HIOXHQW DQG VWUDLQ
LPSURYHPHQW ZH FDQ DFKLHYH UHGXFWRQ SSP LQ &2' YDOXH
ZKLFK LV RXU XOWLPDWH JRDO ,Q QHDU IXWXUH ZH ZLOO EH SHUIRUPLQJ VFDOH
XS VWXGLHV LQ SLORW SODQW ZLWK WKH EDFHULD EDVHG IHUPHQWU 7KH UHV
REWDLQHG IURP SLORW SODQW VWXGLHV FRXOG EH H[WUDSRODWHG IRU VHWWLQ
DQ LQGXFVWULDO VFDOH XS XQLW

,Q WKLW VWXG\ %DFLOOXV FHUHXV VWUDLQ <+ H[KLELWV PD[LXP
WROHUDQFDSURODFWDP ZKLFK LV D ILUVW UHSRUW RI LWV NLQG
6XFK D FDSURODFWDP WROHUDQFH FDQ EH DWWULEXWHG WR VSRUH
IRUPLQJ DELOLW\ D SURFHDWULFDQWHQW RI ZDVW ZDWHU
YDULHV FRQVLGHUDEO\ GXULQJ DGYHUVH FRQGLWLRQV LQ WKH SODQW +LJK
FDSURODFWDP WROHUDQFH RI WKLW VWUDLQ WKXV ZLOO EH SURPLVLQJ LQ
WUHDWPHQW RI 1\ORQ HIOXHQW W\ SODQW OHYHO ,W DOVR H[KLELWV KLJK
FDSURODFWDP GHJUDGDWLRQ FDSURODFWDP GHFUHDVLQJ WKH
FRQWHQW RI V\QWKHWLF PHGLXP WR DQG WKDW RI 1\ORQ ZDVW ZDWHU
E\

&RQFOXVLRQ

7KHUHIRUH %DFLOOXV FHUHXV VWUDLQ <+ LVRODWHG LQ WKLW VWXG\ KDV D
EHWWHU H FDSURODFWDP XWLQJ]DWLRQ SRWHQWLDO FRPSDUHG WR WKRVH RI HD