

# The Optimization of Two Methods for Crystal Growth

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**Abstract** 7KLV VWXG\ UHSUHVHQWV WKH UHVXOWV RI DQ H[SHULPHQWDO ZRUNXVLQJWZR\SHVRIIO\DVKHVDVDFHPHQWUHSOD FHPHQWLQVRIWVRLO VWDELOLVDWLRQ7KHIO\DVKHV)\$DQG)\$XVHGLQWKLV VWXG\DUHE\ SURGXFWVUHVXOWLQJURPDQLQFLQHUDWLRQSURFH VVHVEHWZHHQDQG Û& 7KH VWDELOLVHG VRLO LQ WKLV VWXG\ ZDV DQ LQWHUPHGLDWH SODVWLFLW\VLQ\FOD\H\VRLOZLWKPHGLXPRUJDQLF PDWWHUFHQW7KH H[SHULPHQWDO ZRUNV ZHUH LQLWLDO\ FRQGXFWHG RQ VRLO WUHDWHG ZLWK GLIIHUUHQWVSHUFHQWVJHVRI)\$DQGWRLGHQWL\WKH RSWLXP)\$FRQWQW7KHQ)\$ZDVFKHPLFDQ\DFWLYD WHGE\)\$ZKLFKDKLJKDONDOLQLW\EOHQGLQJWKH RSWLXPFRQWQWRI)\$ ZLWK GLIIHUUHQW SRUWLRQV RI )\$ 7KH LPSURYHPHQW OHYHOV ZHUH HYDOXDWHGGHSHQGHQWRQWKHUHVXOWVREWDLQH GIURPFRQVLVWHQ\FOLPLWV DQG FRPSDFWLRQ WHVWV DORQJ ZLWK WKH UHVXOWV RI XQFRILQHG FRPSUHVVLYH VWUHQJWK8&6 WHVWV ZKLFK ZHUH FRQGXFWHG RQ VSHFLPHQVRIVRLOWUHDWHGZLWK)\$DQG)\$DQGH[SRV HGWRLIIHUHQW SHULRGVRIFXULQJ]HURDQQGD\7KHUHVXOWVLQGLF DWHGKDW WKH)\$DQG)\$XVHGLQWKLVVWXG\HIIHFWLYHO\LPSURY HGWKHSK\VLFDQ DQG JHRWHFKQLFDQ SURSHUWLHV RI WKH VRIW VRLO ZKHU WKH LQGH[ RI SODVWLFLW\3ZDVGHFUHDVHGVLJQLILFDQWOIURPW RZLWK RI)\$KRZHYHUWKHUHZDVDVOLJKWLQFUHDVHLQ3ZLW KWKXVHRI )\$ 0HDQZKLOH RI )\$ ZDV LGHQWLILHG DV WKH RSWLXP SHUFHQWVJHVRI LPSURYLQJ WKH 8&6 RI VWDELOLVHG VRLO VLJQLILFDQWO\ )XUWKHUPRUH)\$ZDVIRXQGHIHFWLYHDVDFKHPLFDQD FWLYDWRUWR)\$ ZKHUWKH8&6ZDVLPURYHGVLJQLILFDQWO\DIWHUX VLQJ)\$

**Keywords** 6RIW VRLO VWDELOLVDWLRQ ZDVWH PDWHULDOV XQFRILQHG FRPSUHVVLYHVWUHQJWK

17528&7,21

2, / VWDELOLVDWLRQ ZDV LQLWLDO\ GLVFRYHUHG DURXQG IRXU

IXPHURXVLQYHVWLJDWLRQVKDYHEHHQFRQGXFW WHGRQVRIWVRLO VWDELOLVDWLRQXVLQJHLWKHUOLPHRU23&DVSUH IHUDEOHFKHPLFDQ

+0- DIHU3RVWJUDGXDWHS5HVHDFK6WXGHQWLVZLWKWKH\LYHU SRRO-RKQ 0RRUHV 8QLYHUVLW\ 6FKRRO RI WKH %XLOW (QYLURQPHQWHPDLO +0-DIHU#OMPXDFXN

'U:\$WKHUWRQ%(QJ+RQV3K')+(\$3URJUDPPH/HDGHULVZLWKW KH 'HSDUWPHQWRI&LYLO(QJLQHHULQJ/LYHUSRRO-RKQ0RRUH V8QLYHUVLW\3HWHU RVW(QWHUSULVH&HQWUH%URP6WUHHW/LYHUSRRO/\$)8.

0V)5XGGFRN%\$+RQV0\$(G03KLO&(,SDUW,,0&.:0 )\$3URJUDPPH/HDGHULVZLWKWK'HSDUWPHQWRI&LYLO(QJ LQHHULQJ 3HWHU-RVW(QWHUSULVH&HQWUH/LYHUSRRO/\$)8.

'U ( /RILO %\$+RQV 06F 3K' 6HQLRU /HFWXUHU LV ZLWK WKH 'HSDUWPHQWRI&LYLO(QJLQHHULQJ/LYHUSRRO-RKQ0RRUHV8QLYHUVLW\&KHULH %RRWK%XLOGLQJ/LYHUSRRO/\$)8.

6RPHRIWKHZDVWHIO\DVKHVKDYHVHOIFHPHQWLQJ SURSHUWLHV

7KLVSDSHUHSUHVHQWVWKHUHVXOWVRIH[SHU LPHQWDOZRUNRQ VRIW VRLO VWDELOLVDWLRQ XVLQJ WZR GLIIHUUHQW VSHV RI ZDVWH IO\ DVKHV)\$DQG)\$E\DGRLWLDQJDELQD\EOHQGLQJ\VW HP

)\$ZDVLQLWLDO\RSWLPLVHGSHSHQGHQWRQWKHU HVXOWVRI8&6 7KH RSWLXP SHUFHQWVJHVRI )\$ ZDV WKHQ FKHPLFDQ\

DFWLYDWHGE\DGGLQJ)\$ZLWKGLIIHUHQWGGWLWR QDOSHUFHQWVJHV

DQG\$008&6VSHFLPHQVZHUHVXEMHFWHGWRL GLIIHUHQWVSHULRGVRIFXULQJ]DQGD\VSULRUWR8&6

6 WHVWLQJ

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## A. Soil Sample

7KHVRLOXVHGLQWKLVVWXG\ZDVVLQ\FOD\FRO OHFWHGIURPWKH

VKRXOGHURIWKH5LYHU\$OWZKLFKLVORFDWHLQ+ LJK7RZQWRWKH

QRUWKRI/LYHUSRRO&LW\&HQWUHLQWKH8QLWHG. LQJGRP)LJ

VKRZWKHPDSVRIWKHVLWHZKHUWKHVRLOVDPSO HVXVHGLQWKLV VWXG\ZHUHH[WUDFWHG

7DEOH , LOOXVWUDWHV WKH PDLQ SK\VLFDQ FKHPLFDQ DQG JHRWHFKQLFDQ SURSHUWLHV RI

WKH VRIW VRLO )URP WKH FXUYH RI SDUWLFOH GLVWULEXWLRQ WKH OLTXLG OLPLW// DQG 3, DQG LQ

DDFRUGDQFHWRWKH8QLLHG6RLO&ODVVLILFDWLR Q6\WHP86&6

WKHVRIWVRLOXVHGLQWKLVVWXG\LVQDQLQWHUPH GLDWHSDVWLFLW\VLQ\FOD\ZLWKVDQG&.

FOD\ZLWKVDQG&.

)LJ6DWHOOLWH,PDJHVRIWKH6LWHRI([WUDFWLRQ/RF  
DWLRQLQ+LJK  
7RZQ

7\$%/(,  
0\$,13+<6,&\$/\$1'(1\*,1((5,1\*3523(57,(62)7+(62)762,/ JFP

JUDPFXELFFHQWLPWHUHN3D NLORSDFVDO

*B. Waste Materials Fly Ashes*

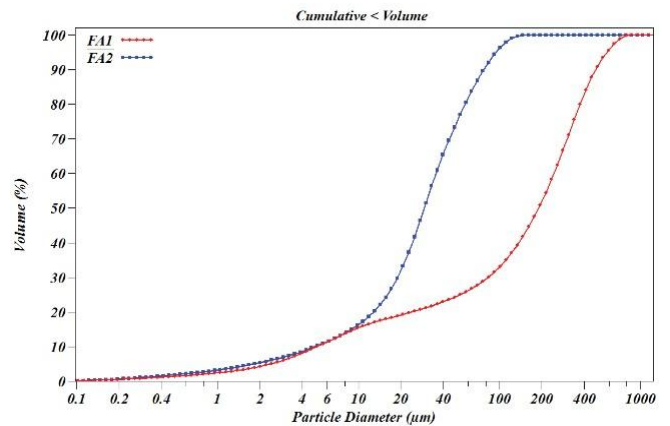
SDUWLFOHVZHUHLQGLFDWHGIRU)\$

DE

)LJ6(0,PDJHVRIWKH)O\$VKHV8VHGLQWKH6WXG\D)\$  
DQGE)\$

)LJ VKRZV WKH FRPSDUDWLYH FXUYHV RI  
SDUWLFOH VLJH  
GLVWULEXWLRQIRUERWKRIWKHIO\DVKHVXVHGLQ  
WKLVVWXG\7KHVH FXUYHV ZHUH REWDLQHG E\  
XVLQJ ODVHU SDUWLFOH VLJH DQDO\VHU  
DSSDUDWXV7KHSUWLFOHVLJHGLVWULEXWLRQW  
HVWLQGLFDWHGKDW)\$  
KDVSDUWLFOHVFRDUVHUWKDQWKRVHIRU)\$DQGW  
KLVDP\DIHFV

WKHSR]]RODQLFUHDFWLYLW\RI)\$



)LJ3DUWLFOH6LJH'LVWULEXWLRQRIWKH)O\$VKHV8V  
HGLQWKH6WXG\

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*A. Methodology*

7KHVRIWVRLOZDVLQWLDOO\WUHDWHGZLWK)\$X  
VLQJGLIIHUHQW  
SHUFHQWDJHV DQGE\WKHG\ZHLJKWRIWKH  
WUHDWHGVRLOWRHYDOXDWHWKHRSWLPXP SHUFH  
QWDJHRI)\$ZKLFK  
ZDVIRXQGWREHHTXDOWR7KHQ)\$ZDVGHHGWRWK  
HRSWLPLVHG)\$VDPSOHLVQWKHRUGHURIDQGE\  
WKHG\ZHLJKWRIWKHWUHDWHGVRLOWRSURGXFH  
GLIIHUHQWELQDU\  
PL[WXUH7DEOH,,VKRZVWKHPL[LQJSURSRUWLRQRI  
)\$DQG  
)\$ZKLFKZDVGRSWHGLQWKHVFRQVWDJHRIWKL  
VVWXG\

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IR	OL[WXUH,'	)\$	)\$
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96 LV WKH YLUJLQ VRLO 8 LV IRU XQDU\ PL[WXUH DQG &%0 LV  
IRU  
FRPSOHPHQWU\ELQDU\PL[WXUH

)RU FRQVLVWHQF\ OLPLWV// 3/ DQG 3, DQG  
FRPSDFWLRQ  
SDUDPHWHUV0"DQG20&WKHVDPHVRIXQWUHDW  
HGDQG  
VRLOWUHDWHGZLWKGLIIHUHQW\SHVRIPL[WXUH  
VZHUHSUHSUDHGE\  
GU\PDQXDOO\PL[LQJIRUDSSUR[LPDWHO\PLQXWHV7  
KHQWDS

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ZDWHUZDVDGGHGWRWKHPL[WXUHVVUDLJKWDZD\ WRSURGXFWHVKH UHTXLUHGSVDVWHVIRUFROGXFWLQJWKHWHVWV ,QWHUPVRI8&6WHVWVDFRQVWDQWYROXPHPRXO GZDVXVHGWR SUHSDUH VSHFLPHQV ZLWK VSHFLILF GLPHQVLRQV PP LQ GLDPHWHU DQG PP LQ KHLJKW E\ SUHVVLQJ WKH VRLOELQGHU SDVWH LQVLGH WKH PRXOG XVLQJ D K\GUDXOLF MDFN \$OO W\SHV RI VSHFLPHQVZHUHFUXHGIRUGLIHUHQWWSHULRGV DQ G GD\VSULRUWREHLQJVXEMHFWHGWR8&6WHVWLQJ

*B.Laboratory Test*

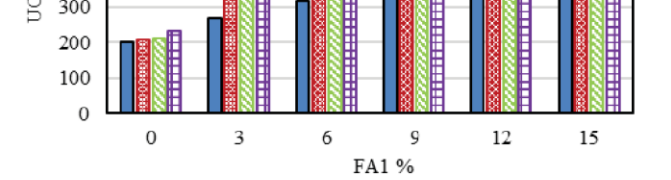
7KUH PDLQ H[SHULPHQV ZHUH FRQGXFWHG LQ WKL VVWX\ WR HYDOXDWH WKH HIIHFW RI XQDU\ DQG ELQDU\ PL[WXUH V RQ WKH SK\VLFDQ DQG JHRWHFKQLFDO SURSHUWLHV RI WKH WUHDWHG VRLO DQG WKHVHWHVWV DUH x &RQVLVWHQ\ OLPLV WHVWLQJ // 3/ DQG 3, 7KLV WHVW ZDV FRQGXFWHG DFRUGLQJ WR %ULWLK VWDQGDUG %6

,9 5(68/76\$1",6&866,21

*A.Optimisation for FA1*

7KHPD[LPXPFPSUHVVLYHVWUHQJWKYDOXHVRE WDLQHGIURP 8&6WHVWLQJRIWKHVRLOWUHDWHGZLWGLIHHUHQ WSHUFHQW DJHVRI )\$DQFXUHGIUGLIHHUHQWWSHULRGV DUVKZRQLQ LJ,WFDQ EH VHHQ WKDW WKH VRLO VVUHQJWK LQFUHDVHGZLWK WKH LQFUHDVH LQ )\$FRQWHQWIRPXS WRDQGWKHQWKH8&6GHFUHDV HG

E\XVLQJRI)\$RUHRYHUWKH8&6YDOXHVZHUHDOVR IRXQGWR LQFUHDVH ZLWKWKHWRPHRIFXULQJIRUDO OSHUFHQW DJHVRI )\$7KHUH VVUHQJWKH8&6WHVWLQJLQGLSDVW HGWKDW WKHRSWLPXP SHUFHQW DJHVRI)\$LVE\WKHG\ZHLJKWRIWKH WUHDWHGVRLO DQGWKLVSUFHQW DJHVRI)\$FROVLGHUHGDU\XQDU\ PL[WXUHLQWKH VHFROGVWDJHVRIWKH[SHULPHQWDOZRUN



)LJ'HYHORSPHQWRI8&6IRUWKH6RLO7UHDWHGZLWK) \$

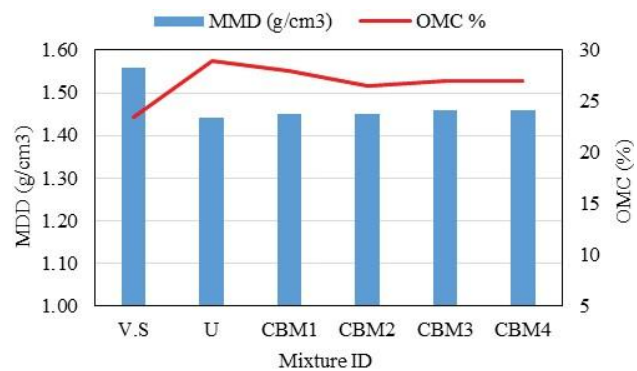
*B.Effect of Chemical Activation by FA2*

7KH HIIHFW RI ELQDU\ EOHQGLQJ PL[WXUH RI )\$ DQG )\$ ZLWK GLIHHUHQW SURSRUWLRQV RQ WKH VRLO FRQVLVWHQ\ OLPLV LV VKRZQLQJDEOH,,,QWKLWDEOHLWDFQEHVHHQWK DWWKHXVHRI ELQGHUZLWKDXQDU\PL[WXUH ZKLFKLVUHSUHVHQ WHGE\RI )\$LQFUHDVHGERWKWKH//DQG3/VLJQLILFDQW\ DQG WKDWOHGWR GHFUHDVHWKH3,RIWKH WUHDWHGVRLOIURPWRRQ O\ +RZHYHU WKH UHVXOW RI WKH \$WWHUEHU OLPLV WHVW LQGLFDWHG VOLJKW UHGXFWRQ LQ ERWK // DQG 3/ ZLWK WKH XVH RI ELQDU\ PL[WXUHVXWVKHUHGXFWRQVWKDWRFFXUHG LQ/VZHUHKLJKHU WKDQ WKRVL IRU SODVWL OLPLV ZKLFK LQ WXUQ OHG WR VOLJKW FRQLQXRXVGHFUHDVH LQ3,ZLWKLQFUHDVHRIWK H)\$DGGHGWR WKH)\$

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)LJKRZVWKHUHVXOWVRIFRPSDFWRQSDUDPHW HUVVHVVIRU WKH VRLO WUHDWHG ZLWK GLIHHUHQW W\SHV RI ELQDU\ PL[WXUH LQ DGGLWRQRWRWKHYLUJLQVRLODQGVRLUWUHDWH GZLWKWKHRSWLPXP SHUFHQW DJHVRI)\$,WFDQEHUFRJLVHGWKDW0"GHF UHDFHG ZKLOH 20& LQFUHDVHG VLJQLILFDQW\ E\ WUHDWLQJ ZLWK RI )\$8QDU\PL[WXUH+RZHYHUWKHUHZHUHFOHUUHGXF WRQLQV LQ 20&ZLWKWKHXVHRI)\$VSHFLDOO\IRU&%0DQ&%0 ZKLOH0"LQFUHDVHGJUDGXDOO\ZLWKDGGHG)\$



)LJ0"20&5HODWLRQVKLSIRUWKH6RLO7UHDWHGZLWK' 0"RIWKHVRLODVGHVFULEHGHUOLHU  
LIIHUHQW

7\SHVRI0L[WXUHV

9&21&/86,216

8&6 UHVXOWV DUH VKRZQ LQ )LJ 7KH UHVXOWV  
LQGLFDWHG D VLJQLILFDQW LPSURYHPPHQW LQ WKH  
VRLO VWUHQJWK ZLWK WKH XVH RI  
ELQDU\PL[WXUHVVHVSFLDOO\ZLWKUHVSHFWWRW  
KHVRLOWUHDWHGZLWK &%0 DQG &%0 ZKLFK  
LQGLFDWHG YHU\ VLPLODU UHVXOWV  
0RUHRYHUWKHUHVXOWVLQGLFDWHGDUJUDGXDOL  
QFUHDVHLOQ&6IRU  
]HURGD\VRIFXULQJZLWKXVHRI)\$GXHWRWKHLQFUH  
DVHLQ

\$FFRUGLQJ WR WKH UHVXOWV DFKLHYHG LQ  
WKLW VWXG\ WKH  
IROORZLQJFRQFOXVLRQVFDQEHGUDZQ  
x7KHUHVXOWVLQGLFDWHGWKDWRI)\$ZDVWKHRSWLPXP  
SHUFHQWDJHZKLFKZDVHQRXJKWRLQFUHDVHWKH8&6RIWKH  
WUHDWHGVRLOE\DQDSSUR[LPDWHIDFWRURIDIWHUGD\V  
RIFXULQJ  
x\$WWHUEHUJ OLPLWV IRU WKH VRLO XVHG LQ WKLW VWXG  
ZHUH  
LPSURYHGV LJQLILFDQW\ZLWKXVHRI)\$ZKLOHWKHUH

xZDV QR VLJQLILFDQW LPSURYHPPHQW ZLWK XVH RI )\$  
+RZHYHU3,GHFUHDVHIURPIRUYLULQVRLWR E\XVLQJ&%0)\$  
:LWK UHVSHFW WR 8&6 WHVWLQJ WKH UHVXOWV LQGLFDWHG  
WKDW  
WUHDWLQJVRIRIWRLOZLWKELQDU\PL[WXUHLPSURYHGWKH8&6  
VLJQLILFDQW\ ZLWK &%0 DQG &%0 UHYHDOLQJ VLPLODU  
UHVXOWV+RZHYHULQWHUPV RIHFRQRPLFVDYLQJV&%0  
FDQEHFRQVLGHUHGDUJUDGXVWKHRSWLPXPPELQDU\PL[WXUHLQWKLW  
VWXG\ZKLFKLVGHULYHGIURP)\$ZLWK)\$7KLV  
PL[WXUHLPSURYHGWKH8&6EIDFWRURIDIWHUGD\V RIFXULQJ

IOXLGFDWDO\WLFUDFNLQJFDWDO\VWUHVLGXHWHU  
&RQVWUXFWLRQDQG%XLOGLQJ0DWHULDOV

J'HYHORSPPHQWLQ&6IRUWKH6RLO7UHDWHGZLWK'LIIHUHQW7\SHV  
RI0L[WXUHVDQGG&XUHGIRU'LIIHUHQW3HULRGVRI&XULQJ

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7KHILUVWDXWKRUZRROGOLNHWRH[ SUHVVKLVDFNQRZOHGJPHQW  
WRWKH,UDTLPLQLVWU\RIKLIKHXGFDWLRQDQGVFLHQWLILFUHVHDFK  
DQG WKH 8QLYHUVLW\ RI %DE\ORQ FROOHJH RI HQJLQHULQJ  
%DE\ORQ±,UDTIRUIXQGLQJ