Appendix A

Sample code for electrochemical model of nanomaterial based ENFETs

```
% Diffusion model
alpha=(aM*nenz)/(Ds*kM);
xi=1;
ti=1;
for t=0:1:n
SLt(ti)=-aM*nenz*t + S0;
PLt(ti)=S0-SLt(ti);
for x=0:.000001:L
if x<=L
Sxt(xi,ti)=(cosh(x*(sqrt(alpha)))/cosh(L*(sqrt(alpha))))*SLt(ti);
Pxt(xi,ti)=(Ds/Dp)*(1-(cosh(x*alpha^.5)/cosh(L*alpha^.5)))*SLt(ti)+PLt(ti);
else
Sxt(xi,ti)=S0;
Pxt(xi,ti)=0;
end
xi=xi+1;
end
xi=1;
ti=ti+1;
end
xp=0:.000001:L;
figure
subplot(121),plot(xp,Sxt)
title('Substrate concentration vs diffusion length')
xlabel('Diffusion length in cm')
ylabel('Substrate concentration in mol/cm^3')
subplot(122),plot(xp,Pxt)
title('Product concentration vs diffusion length')
xlabel('Diffusion length in cm')
ylabel('Product concentration in mol/cm^3')
```

```
%pH variations due to acid/base reactions
for t=1:m
for j=1:n
pKe=-log(Ke)/2.303;
Ct=(10^(-pH0))-(10^-(pKe-pH0));
p(j,:,t)=[1 -Ct -Ka.*Pxt(j,t)-Ke];
r(j,:,t)=roots(p(j,:,t));
H(j,t)=max(real(r(j,:,t)));
pH(j,t)=-log(H(j,t))/2.303;
end
end
xp=0:.0000005:L;
figure
plot(xp,pH);
title('pH vs diffusion length')
xlabel('diffusion length in cm')
ylabel('pH')
figure
plot(PLt,pH)
title('pH vs Product concentration')
xlabel('Product concentration in mol/cm^3')
ylabel('pH')
%Surface potential variation using Bousse’s model
delta=2*(Ka*Kb)^.5;
beta=((q^2)*Ns*delta)/(Ceq*k*T)
pHpzc=-log10((Ka/Kb)^.5)
sen=(2.303*k*T/q)*(beta/(beta+1));
pot=sen*(pHpzc-pH); %Bousse's Model
figure
plot(pH,pot)
title('Surface potential vs pH')
xlabel('pH')
ylabel('surface potential in V')
%Threshold voltage variation
```

```
Cox=eox/tox;
Qox=q*Nox;
phif=(k*T/q)*log(Nd/ni);
Vth=Eref-pot+Xsol-phis-(Qs+Qox+Qss)./Cox+(2*phif);
figure
plot(pH,Vt);
title('Threshold voltage vs pH')
xlabel('pH')
ylabel('Threshold voltage in V')
%Current transport model
c=0;
for i=0:q
c=c+1;
Vt1=Vt(c,1);
Vgs=.4;
Id1=0;
k=(Cox*mobility*W/L);
j=0;
for Vds=0:.05: Vdsmax
   j=j+1;
if Vgs<Vt1 || Vds==0
   Id=0;
elseif Vds<(Vgs-Vt1)
   Id=k*((Vgs-Vt1)*Vds-(Vds.^2)/2);
else
   Id=(k./2)*(Vgs-Vt1).^2;
end
Id1(j) =[Id];
end
Id2(:,c)=Id1;
end
Vds=0:.05: Vdsmax
figure
plot(Vds,Id2)
```