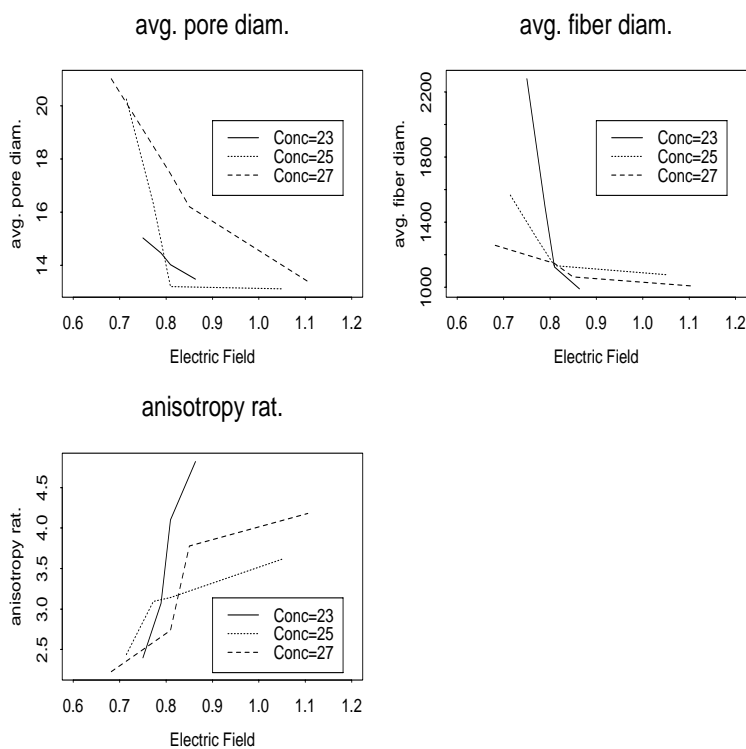


## Brief analysis of data from Abhay's electrospinning experiments

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This analysis investigates associations between pore diameter (apd), fiber diameter (AFD), anisotropy (AR) and the process parameters electric field (EF) and concentration (CONC).

Previous analyses indicated quadratic and linear dependencies of AFD on EF, depending on the level of CONC. Associations can also be seen for the other two responses, APD and AR, in the plot below.



These plots indicate that APD and AFD are decreasing in EF, while AR is increasing in EF. For APD, a test of a single quadratic profile with different intercepts (reduced model) against an interaction model, with different quadratic profiles for the three concentrations (full model) is statistically significant ( $F = 14.49$ ,  $p = 0.0265$ ,  $df = 4, 3$ ). The full model, based on observations at four electric fields for each of three concentrations, explains more than 99% of the observed variation. Output on the next page.

The GLM Procedure

Dependent Variable: apd

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	8	80.07833687	10.00979211	56.93	0.0034
Error	3	0.52748529	0.17582843		
Corrected Total	11	80.60582216			

R-Square	Coeff Var	Root MSE	apd Mean
0.993456	2.676431	0.419319	15.66710

Source	DF	Type I SS	Mean Square	F Value	Pr > F
ef	1	34.87041454	34.87041454	198.32	0.0008
ef*ef	1	21.39579143	21.39579143	121.69	0.0016
Conc	2	13.62120774	6.81060387	38.73	0.0072
ef*Conc	2	1.67379900	0.83689950	4.76	0.1173
ef*ef*Conc	2	8.51712416	4.25856208	24.22	0.0141

Parameter	Estimate	Standard Error	t Value	Pr >  t
Intercept	62.3490330 B	8.4924447	7.34	0.0052
ef	-86.7892137 B	19.1949062	-4.52	0.0202
ef*ef	38.4488978 B	10.5594723	3.64	0.0357
Conc 23	-9.9426757 B	89.6761259	-0.11	0.9187
Conc 25	129.8865449 B	19.2274471	6.76	0.0066
Conc 27	0.0000000 B	.	.	.
ef*Conc 23	5.7621347 B	222.1240862	0.03	0.9809
ef*Conc 25	-302.5350476 B	43.8583388	-6.90	0.0062
ef*Conc 27	0.0000000 B	.	.	.
ef*ef*Conc 23	3.1798616 B	137.2575490	0.02	0.9830
ef*ef*Conc 25	169.8651305 B	24.4172682	6.96	0.0061
ef*ef*Conc 27	0.0000000 B	.	.	.

The associations between the response AR and the process parameters EF and CONC is more difficult to model, as the AR profile in EF appears s-shaped for fixed concentration. A quadratic model doesn't fit well, but a linear model w/ EF\*CONC interaction captures much of the variability in AR  $r^2 = 0.88$ . Output below

The GLM Procedure

Dependent Variable: ar

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	5	6.38496550	1.27699310	9.25	0.0087
Error	6	0.82870131	0.13811689		
Corrected Total	11	7.21366682			

R-Square	Coeff Var	Root MSE	ar Mean
0.885121	11.26235	0.371641	3.299852

Source	DF	Type I SS	Mean Square	F Value	Pr > F
Conc	2	0.58494856	0.29247428	2.12	0.2015
ef	1	3.55826344	3.55826344	25.76	0.0023
ef*Conc	2	2.24175350	1.12087675	8.12	0.0197

Source	DF	Type III SS	Mean Square	F Value	Pr > F
Conc	2	2.03859357	1.01929679	7.38	0.0241
ef	1	5.00450249	5.00450249	36.23	0.0009
ef*Conc	2	2.24175350	1.12087675	8.12	0.0197

Parameter	Estimate	Standard Error	t Value	Pr >  t
Intercept	-0.69820013 B	1.05791969	-0.66	0.5338
Conc 23	-13.43981579 B	3.79464813	-3.54	0.0122
Conc 25	1.33093025 B	1.62293320	0.82	0.4435
Conc 27	0.00000000 B	.	.	.
ef	4.55904916 B	1.20869365	3.77	0.0093
ef*Conc 23	17.52741001 B	4.69050498	3.74	0.0097
ef*Conc 25	-1.64449077 B	1.89093269	-0.87	0.4179
ef*Conc 27	0.00000000 B	.	.	.

*Partial correlation coefficients* can be used to describe linear associations between pair of response variables after accounting for effects due to electric field and concentration. The partial correlation between APD and AFD after accounting for EF and CONC is  $r_{APD.AFD,model} = (0.46)^2 = 0.207$ . partial correlation between APD and AR after accounting for EF and CONC is  $r_{APD.AR,model} = (-0.11)^2 = 0.0127$ . Neither of these correlations are statistically significant. Though there is some evidence of marginal negative association between APD and AR,  $r = -0.70, p = 0.012$ , the linear association goes away dependence on EF and CONC are accounted for in the model. Partial correlations can obtained in SAS using either the PCORR1 option within PROC REG or by generating the necessary residuals from the appropriate models and then using PROC CORR to get correlations. Output from both procedures below.

The CORR Procedure  
 Pearson Correlation Coefficients, N = 12  
 Prob > |r| under H0: Rho=0

	rapd	rafd	rar
rapd	1.00000	0.45547	-0.11267
rafd	0.45547	1.00000	-0.80471
rar	-0.11267	-0.80471	1.00000

The REG Procedure  
 Model: MODEL1  
 Dependent Variable: apd

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	80.18777	8.90975	42.62	0.0231
Error	2	0.41806	0.20903		
Corrected Total	11	80.60582			

Root MSE                      0.45720      R-Square                      0.9948

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr >  t	Squared Partial Corr Type I
Intercept	1	49.69153	19.79316	2.51	0.1287	.
c1	1	-422.06490	577.91803	-0.73	0.5412	0.14872
c2	1	90.74062	58.02258	1.56	0.2583	0.04896
ef	1	-71.18927	30.04769	-2.37	0.1413	0.71358
ef2	1	31.16268	15.29587	2.04	0.1785	0.42656
efc1	1	981.07269	1369.54339	0.72	0.5481	0.13877
efc2	1	-216.41334	128.27408	-1.69	0.2336	0.02019
ef2c1	1	-573.05651	810.34515	-0.71	0.5528	0.00084429
ef2c2	1	123.06821	69.94222	1.76	0.2206	0.94163
afd	1	0.00429	0.00593	0.72	0.5445	0.20746

Model: MODEL2  
 Dependent Variable: apd  
 Analysis of Variance

Source	DF	Sum of Squares	Mean Square	F Value	Pr > F
Model	9	80.08503	8.89834	34.17	0.0287
Error	2	0.52079	0.26039		
Corrected Total	11	80.60582			

Root MSE	0.51029	R-Square	0.9935
Dependent Mean	15.66710	Adj R-Sq	0.9645
Coeff Var	3.25707		

Parameter Estimates

Variable	DF	Parameter Estimate	Standard Error	t Value	Pr >  t	Squared Partial Corr	Type I
Intercept	1	61.33551	12.11415	5.06	0.0369	.	
c1	1	-14.77128	113.20858	-0.13	0.9081	0.14872	
c2	1	129.29021	23.69240	5.46	0.0320	0.04896	
ef	1	-84.14014	28.60990	-2.94	0.0988	0.71358	
ef2	1	37.27680	14.78347	2.52	0.1278	0.42656	
efc1	1	16.11406	277.91377	0.06	0.9590	0.13877	
efc2	1	-300.99367	54.23176	-5.55	0.0310	0.02019	
ef2c1	1	-2.12043	170.27354	-0.01	0.9912	0.00084429	
ef2c2	1	168.88285	30.33924	5.57	0.0308	0.94163	
ar	1	-0.11490	0.71647	-0.16	0.8873	0.01270	