

Persistence Experiments

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Analysis of Persistence Experiments

Dataset A

```
# Read in A data
my.dat = read_xlsx("dat/Counts_data.xlsx", sheet = "A")

# use the persistence experiments for Groups 1 & 2.
persist.dat = my.dat %>% filter(
  Substrate != 'Cott01' &
  Experiment %in% c(1,2) &
  ObservationType != 'Ndata') %>%
select(c("Substrate", "ObservationType", "Count", "Mass (g)", "TransferTime (s)",
  "PersistenceTime (min)", "Experiment", "Replicate")) %>%
dplyr::rename(Mass = `Mass (g)`,
  TransferTime = `TransferTime (s)`,
  PersistenceTime = `PersistenceTime (min)`)

# fix column types
persist.dat$Count = as.numeric(persist.dat$Count)
persist.dat$PersistenceTime = as.numeric(persist.dat$PersistenceTime)
persist.dat$Experiment = as.character(persist.dat$Experiment)
persist.dat$Replicate = as.character(persist.dat$Replicate)
# some errors in the data, fix
persist.dat[persist.dat$Substrate == 'wool01', 'Substrate'] <- 'Wool'
persist.dat[persist.dat$Substrate == 'Wool01', 'Substrate'] <- 'Wool'
persist.dat[persist.dat$Substrate == 'Nylo01', 'Substrate'] <- 'Nylon'
persist.dat[persist.dat$Substrate == 'Wool' & persist.dat$Experiment == '2', 'Substrate'] <- 'Nylon'
# summarise the count data
summ.dat = summarySE(persist.dat, measurevar = "Count", groupvars = c("Substrate", "PersistenceTime",
  "Experiment"))
knitr::kable(head(summ.dat), caption = "Summary of A Persistence Data")
```

Table 1: Summary of A Persistence Data

| Substrate | PersistenceTime | Experiment | N | Count | sd | se | ci |
|-----------|-----------------|------------|---|----------|-----------|----------|-----------|
| Nylon | 0 | 2 | 6 | 49.83333 | 24.449267 | 9.981371 | 25.657932 |
| Nylon | 30 | 2 | 6 | 30.33333 | 22.033308 | 8.995060 | 23.122539 |
| Nylon | 60 | 2 | 6 | 22.00000 | 14.615061 | 5.966574 | 15.337566 |
| Nylon | 120 | 2 | 6 | 15.00000 | 14.669697 | 5.988879 | 15.394903 |
| Nylon | 180 | 2 | 6 | 11.83333 | 9.907909 | 4.044887 | 10.397713 |
| Nylon | 360 | 2 | 6 | 3.50000 | 3.507136 | 1.431782 | 3.680513 |

```

p1 = ggplot(summ.dat, aes(x=PersistenceTime, y = Count, group = Substrate, colour =
                        Substrate, shape=Substrate)) +
  geom_point(position = position_dodge(0.3)) +
  geom_errorbar(aes(ymin = Count-se, ymax = Count+se), width = 0.08) +
  xlim(c(-5,1500)) +
  scale_y_continuous(breaks = seq(0,60,10)) +
  scale_color_brewer(palette = 'Paired') +
  labs(x = "Persistence Time (min)",
       y = "Particle Count",
       caption = "Error bars: std error") +
  mytheme +
  theme_pubr()

p2 = ggplot(summ.dat, aes(x=PersistenceTime, y = Count, group = Substrate, colour =
                        Substrate, shape=Substrate)) +
  geom_point(position = position_dodge(0.3)) +
  geom_errorbar(aes(ymin = Count-se, ymax = Count+se), width = 0.08) +
  scale_color_brewer(palette = 'Paired') +
  labs(x = "Persistence Time (min)",
       y = "Particle Count") +
  theme_pubr() +
  theme(axis.title = element_text(size = 8),
        axis.text = element_text(size = 8),
        legend.title = element_blank(),
        legend.position = 'NA')

p1 + annotation_custom(ggplotGrob(p2), xmin = 700, xmax = 1600,
                      ymin = 20, ymax = 65)

```

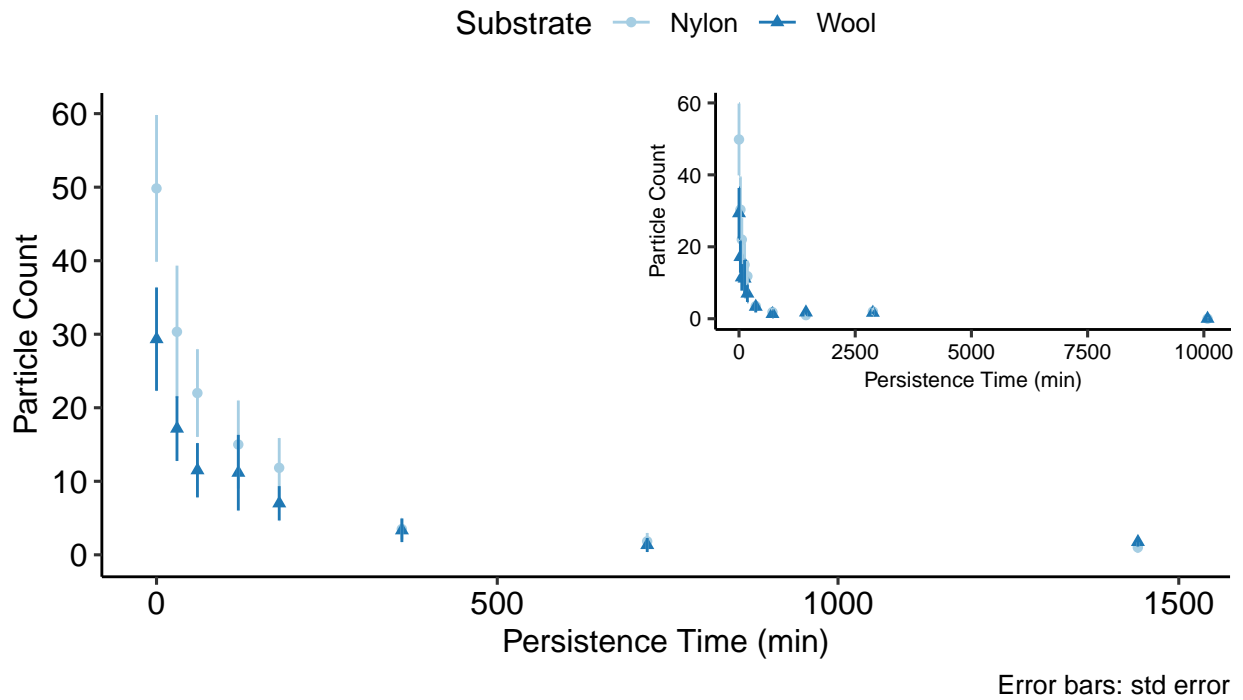


Figure S1: Particle count for Nylon and Wool as receiver materials

```
# ideas taken from http://douglas-watson.github.io/post/2018-09\_exponential\_curve\_fitting/
# and https://dataconomy.com/2017/08/nonlinear-least-square-nonlinear-regression-r/
set.seed(12345)
ny.fit = nls(Count ~ SSasympt(PersistenceTime, Countf, Count0, log_alpha),
             data = summ.dat,
             subset = Substrate == 'Nylon')
ny.fit.err = summ.dat$Count - predict(ny.fit)
ny.nlm_error <- sqrt(mean(ny.fit.err^2))
ny.fit
```

```
## Nonlinear regression model
## model: Count ~ SSasympt(PersistenceTime, Countf, Count0, log_alpha)
## data: summ.dat
## Countf Count0 log_alpha
## 2.060 47.063 -4.458
## residual sum-of-squares: 52.85
##
## Number of iterations to convergence: 0
## Achieved convergence tolerance: 5.673e-06
```

The residual error is: 6.42217

```
pts = seq(0, max(summ.dat$PersistenceTime), length=200)
gg.fit = data.frame(y=predict(ny.fit, data.frame(PersistenceTime = pts)), x= pts)

p1 = ggplot(summ.dat[summ.dat$Substrate == 'Nylon',], aes(x = PersistenceTime, y = Count)) +
  labs(
    x = "Persistence Time (min)",
    y = "Particle Count") +
  geom_point(colour = '#a6cee3') +
  geom_errorbar(aes(ymin = Count-se, ymax = Count+se), width = 0.08, data =
    summ.dat[summ.dat$Substrate == 'Nylon',], colour = '#a6cee3') +
  geom_line(aes(x = x, y = y), data = gg.fit, colour = '#a6cee3') +
  xlim(c(-5, 1500)) +
  mytheme +
  theme_pubr()

p2 = ggplot(summ.dat[summ.dat$Substrate == 'Nylon',], aes(x = PersistenceTime, y = Count)) +
  labs(x = "Persistence Time (min)",
    y = "Particle Count") +
  geom_point(colour = '#a6cee3') +
  geom_errorbar(aes(ymin = Count-se, ymax = Count+se), width = 0.08, data =
    summ.dat[summ.dat$Substrate == 'Nylon',], colour = '#a6cee3') +
  geom_line(aes(x = x, y = y), data = gg.fit, colour = '#a6cee3') +
  theme_pubr() +
  theme(axis.title = element_text(size = 8),
    axis.text = element_text(size = 8),
    legend.title = element_blank(),
    legend.position = 'NA')

nplt <- p1 + annotation_custom(ggplotGrob(p2), xmin = 700, xmax = 1600,
  ymin = 20, ymax = 65)
nplt
```

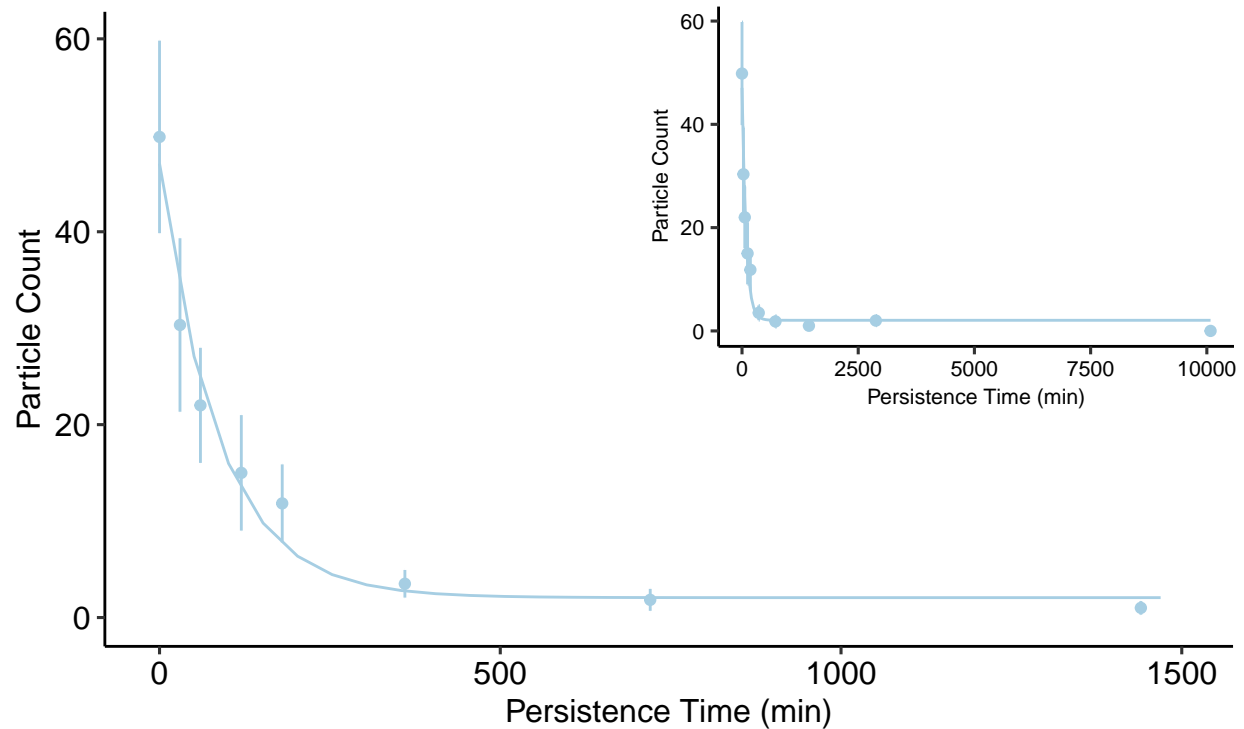


Figure S2: Curve fitting for Nylon as receiver material.

```
wl.fit = nls(Count ~ SSasymp(PersistenceTime, Countf, Count0, log_alpha),
            data = summ.dat,
            subset = Substrate == 'Wool')
wl.fit.err = summ.dat$Count - predict(wl.fit)
wl.nlm_error <- sqrt(mean(wl.fit.err^2))
wl.fit
```

```
## Nonlinear regression model
## model: Count ~ SSasymp(PersistenceTime, Countf, Count0, log_alpha)
## data: summ.dat
## Countf Count0 log_alpha
## 1.908 27.132 -4.449
## residual sum-of-squares: 38.19
##
## Number of iterations to convergence: 0
## Achieved convergence tolerance: 4.898e-06
```

Residual error: 6.42218

```
# generate more points for smooth regression line
pts = seq(0, max(summ.dat$PersistenceTime), length=200)
gg.fit = data.frame(y=predict(wl.fit, data.frame(PersistenceTime = pts)), x= pts)
```

```
p1 = ggplot(summ.dat[summ.dat$Substrate == 'Wool',], aes(x = PersistenceTime, y = Count)) +
  labs(
    x = "Persistence Time (min)",
    y = "Particle Count",
    caption = "Error bars: std error") +
```

```

geom_point(colour = '#1f78b4') +
geom_errorbar(aes(ymin = Count-se, ymax = Count+se), width = 0.08,
              data = summ.dat[summ.dat$Substrate == 'Wool',], colour = '#1f78b4') +
geom_line(aes(x = x, y = y), data = gg.fit, colour = '#1f78b4') +
xlim(c(-5,1500)) +
mytheme +
theme_pubr()

p2 = ggplot(summ.dat[summ.dat$Substrate == 'Wool',], aes(x = PersistenceTime, y = Count)) +
  labs(
    x = "Persistence Time (min)",
    y = "Particle Count") +
  geom_point(colour = '#1f78b4') +
  geom_errorbar(aes(ymin = Count-se, ymax = Count+se), width = 0.08,
                data = summ.dat[summ.dat$Substrate == 'Wool',], colour = '#1f78b4') +
  geom_line(aes(x = x, y = y), data = gg.fit, colour = '#1f78b4') +
  theme_pubr() +
  theme(axis.title = element_text(size = 8),
        axis.text = element_text(size = 8),
        legend.title = element_blank(),
        legend.position = 'NA')

wplt = p1 + annotation_custom(ggplotGrob(p2), xmin = 700, xmax = 1600,
                             ymin = 10, ymax = 40)
wplt

```

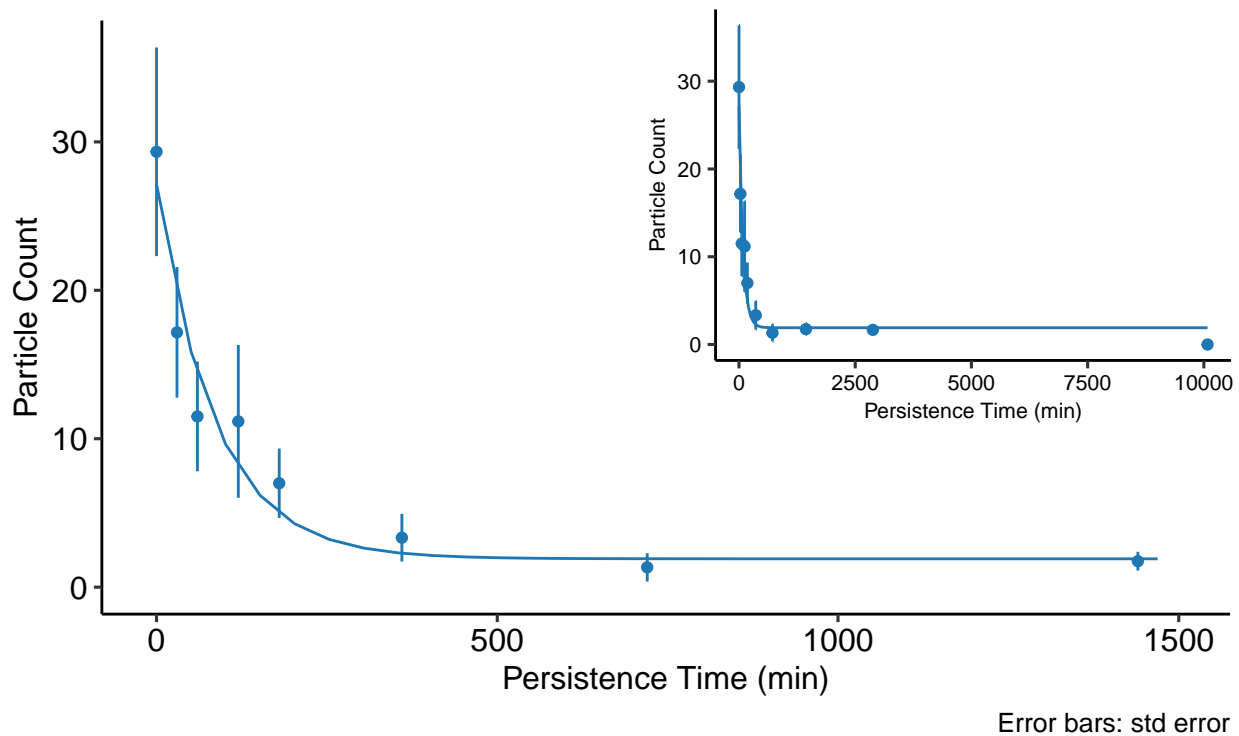


Figure S3: Curve fitting for Wool as receiver material.

```

arrplot = ggarrange(nplt + rremove('x.title'), wplt, labels = c('A', 'B'), nrow = 2)
#ggsave("persistence.png", arrplot, height = 4.5, units = 'in')
arrplot

```

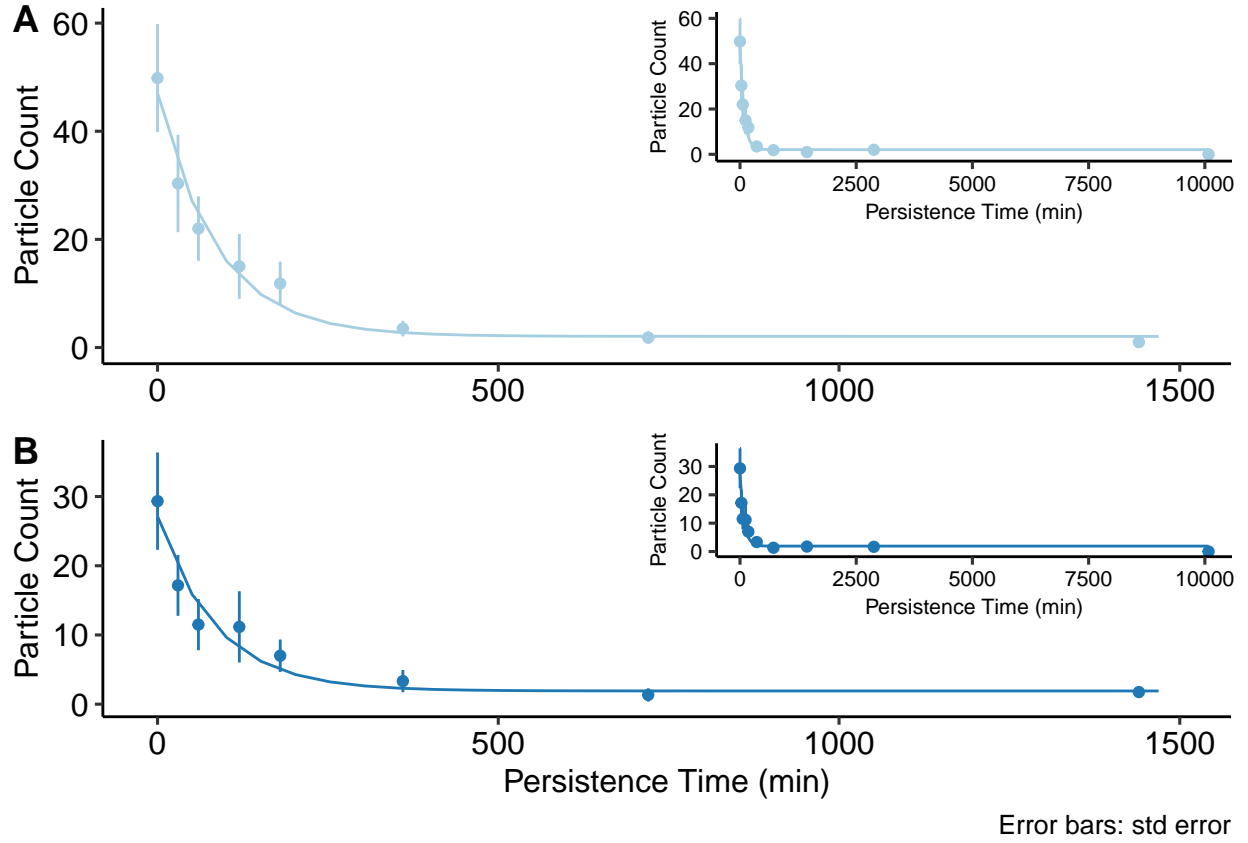


Figure S4: Comparison between (A) Nylon and (B) Wool as receiver materials

```
summ.dat$Experiment <- as.numeric(summ.dat$PersistenceTime)
cmp.fit.dat = summ.dat %>%
  group_by(Substrate) %>%
  do(fit = nls(Count ~ SSasymp(PersistenceTime, Countf, Count0, log_alpha), data = .)) %>%
  ungroup %>%
  mutate(fitCoef = map(fit, tidy)) %>%
  select(Substrate, fitCoef) %>%
  unnest(fitCoef) %>%
  select(Substrate, term, estimate) %>%
  spread(term, estimate) %>%
  mutate(alpha = exp(log_alpha))
knitr::kable(cmp.fit.dat)
```

| Substrate | Count0 | Countf | log_alpha | alpha |
|-----------|----------|----------|-----------|-----------|
| Nylon | 47.06339 | 2.060017 | -4.457615 | 0.0115900 |
| Wool | 27.13156 | 1.908363 | -4.449466 | 0.0116848 |

Datasets B, C & D

No persistence data available. Data acquisition focussed on the transfer study only.

Dataset E

```
# Read in E data
my.dat = read_xlsx("dat/Counts_data.xlsx", sheet = "E", trim_ws = TRUE, col_types = "text")

# use exp 7 & 8
persist.dat = my.dat %>% filter(
  Substrate != 'Cott01' &
  Experiment %in% c(7,8) &
  Replicate > 7 &
  ObservationType != 'Ndata') %>%
select(c("Substrate", "ObservationType", "Count", "Mass (g)",
  "PersistenceTime (min)", "Experiment", "Replicate", "Note")) %>%
dplyr::rename(Mass = `Mass (g)`,
  PersistenceTime = `PersistenceTime (min)`)

# fix column types
persist.dat$Count = as.numeric(persist.dat$Count)
persist.dat$PersistenceTime = as.numeric(persist.dat$PersistenceTime)
persist.dat$Experiment = as.character(persist.dat$Experiment)
persist.dat$Replicate = as.character(persist.dat$Replicate)

# summarise the count data
summ.dat = summarySE(persist.dat, measurevar = "Count",
  groupvars = c("Substrate", "PersistenceTime", "Experiment", "Note"))
knitr::kable(summ.dat, caption = "Summary of E Persistence Data")
```

Table 3: Summary of E Persistence Data

| Substrate | PersistenceTime | Experiment | Note | N | Count | sd | se | ci |
|-----------|-----------------|------------|------|---|-------|-----------|------|-----------|
| Nylo01 | 0 | 7 | C1 | 2 | 48.5 | 4.949747 | 3.5 | 44.47172 |
| Nylo01 | 0 | 8 | C2 | 2 | 84.0 | 16.970563 | 12.0 | 152.47446 |
| Nylo01 | 30 | 7 | C1 | 2 | 37.5 | 4.949747 | 3.5 | 44.47172 |
| Nylo01 | 30 | 8 | C2 | 2 | 76.0 | 7.071068 | 5.0 | 63.53102 |
| Nylo01 | 60 | 7 | C1 | 2 | 46.5 | 21.920310 | 15.5 | 196.94617 |
| Nylo01 | 60 | 8 | C2 | 2 | 81.5 | 2.121320 | 1.5 | 19.05931 |
| Nylo01 | 120 | 7 | C1 | 1 | 30.0 | NA | NA | NaN |
| Nylo01 | 120 | 8 | C2 | 1 | 78.0 | NA | NA | NaN |
| Nylo01 | 180 | 7 | C1 | 1 | 14.0 | NA | NA | NaN |
| Nylo01 | 180 | 8 | C2 | 1 | 52.0 | NA | NA | NaN |
| Nylo01 | 360 | 7 | C1 | 1 | 3.0 | NA | NA | NaN |
| Nylo01 | 360 | 8 | C2 | 1 | 8.0 | NA | NA | NaN |
| Nylo01 | 720 | 7 | C1 | 1 | 1.0 | NA | NA | NaN |
| Nylo01 | 720 | 8 | C2 | 1 | 8.0 | NA | NA | NaN |
| Nylo01 | 1440 | 7 | C1 | 2 | 5.5 | 6.363961 | 4.5 | 57.17792 |
| Nylo01 | 1440 | 8 | C2 | 2 | 8.0 | 11.313709 | 8.0 | 101.64964 |
| Nylo01 | 2880 | 7 | C1 | 1 | 2.0 | NA | NA | NaN |
| Nylo01 | 2880 | 8 | C2 | 1 | 3.0 | NA | NA | NaN |
| Nylo01 | 10080 | 7 | C1 | 1 | 0.0 | NA | NA | NaN |
| Nylo01 | 10080 | 8 | C2 | 1 | 0.0 | NA | NA | NaN |

Insufficient number of replicates for comprehensive analysis: only 2 replicates for 0, 30, 60 and 1440 minutes, all the other results are single-point.

```
summ.dat = persist.dat %>%
  group_by(Substrate, PersistenceTime, Note) %>%
  summarise(N = n(), Mean = mean(Count), Max = max(Count), Min = min(Count))

ggplot(summ.dat, aes(x=PersistenceTime, y = Mean, colour = Note)) +
  geom_point() +
  geom_linerange(aes(ymin = Min, ymax = Max)) +
  scale_color_brewer(palette = 'Paired') +
  xlim(c(-10, 1500)) +
  labs(title = "Nylon Persistence",
       subtitle = "By different camera settings",
       x = "Persistence Time (min)",
       y = "Particle Count",
       caption = "Error bars: min-max") +
  mytheme +
  theme_pubr()
```

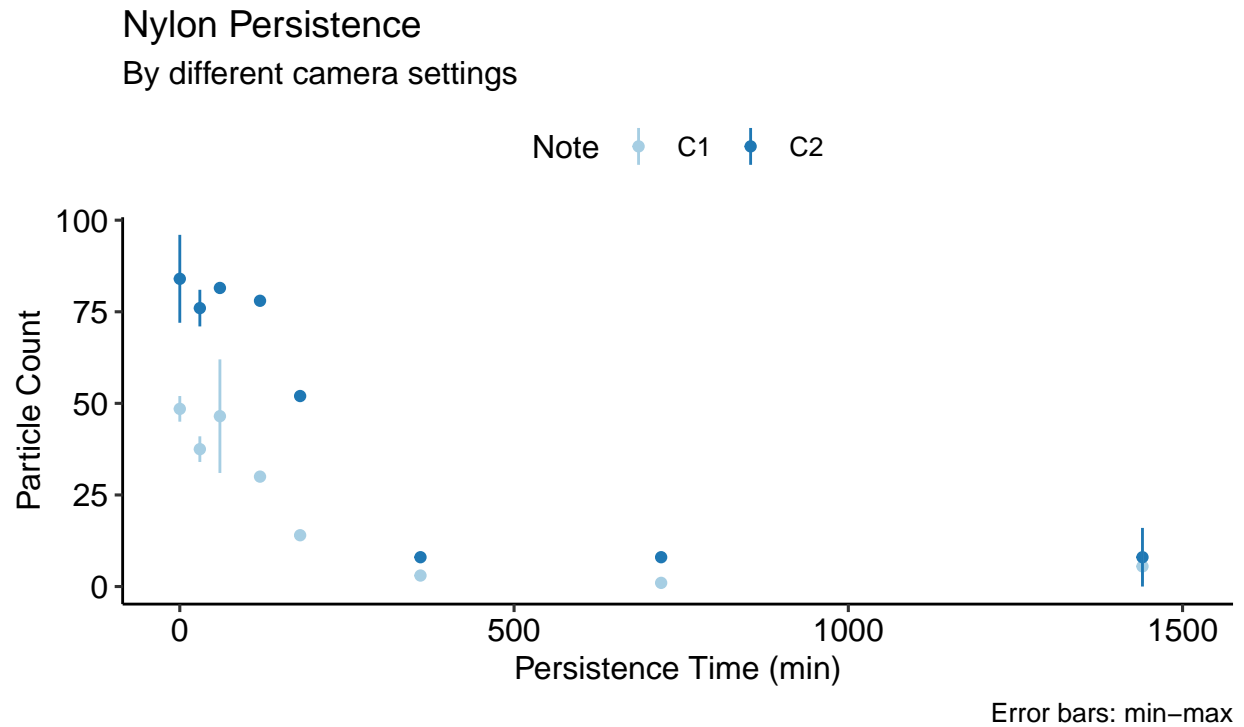


Figure S5: Nylon as receiver material, comparison between camera settings.